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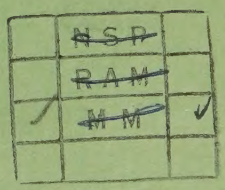
TERRITORY OF PAPUA AND NEW GUINEA

DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES

Annual Report 1961-63



PORT MORESBY, APRIL, 1965

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DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES

Annual Report 1961-63

PORT MORESBY, APRIL, 1965

His Honour the Administrator,
Sir Donald Cleland, C.B.E., O.St.J.,
Port Moresby.

Your Honour,

I have the honour to submit herewith the Annual Report of the Department of Agriculture, Stock and Fisheries for the two years ending 30th June, 1963.

F. C. HENDERSON
Director

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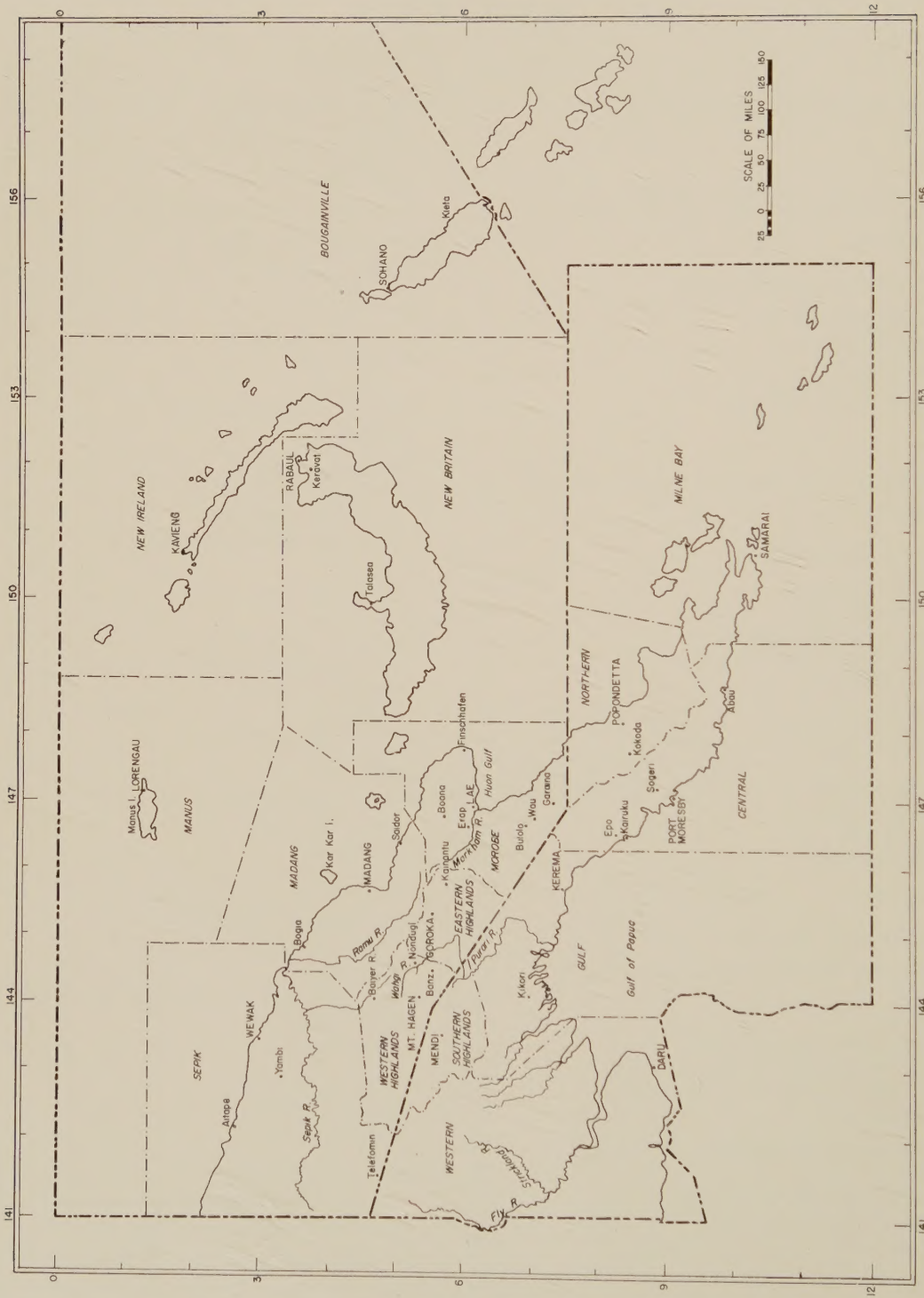

Figure 1: Territory of Papua and New Guinea, showing Administrative Districts, District Headquarters, and locations of Departmental Stations.

Annual Report of the Department of Agriculture, Stock and Fisheries 1961-63

THE TERRITORY OF PAPUA AND NEW GUINEA

POLITICAL

The island of New Guinea and its associated islands are divided politically into three areas. The western part of the mainland is administered by Indonesia and the eastern part is administered by Australia. The latter is sub-divided into the Territory of Papua, which is Australian territory, and the Territory of New Guinea, which is administered by Australia in trust from the United Nations Organisation.

The Territory of Papua comprises the southern portion of the eastern half of the island of New Guinea together with a large number of geographically associated islands, the most important of which are the D'Entrecasteaux group and the Louisiade archipelago.

The Territory of New Guinea consists of the northern part of the eastern half of the main island of New Guinea and the major islands of New Britain, New Ireland, New Hanover, Manus, Buka and Bougainville, together with several hundred smaller islands. The geographical boundaries of the Territory of Papua and New Guinea are shown in Figure 1.

The population of Papua and New Guinea is somewhat less than 2,000,000 people of whom a little more than 500,000 are in Papua. There are large areas, especially in the swampy lowlands of Eastern Papua, with very low population densities. The most populous areas are in the New Guinea highlands where population density exceeds 500 per square mile in limited areas, and the Sepik District.

The basis of the Territory's legislative, administrative and judicial systems is the *Papua and New Guinea Act* 1949-63, of the Commonwealth of Australia, which came into force on 1st July 1949. The Act provided for the administration of the Territory of Papua in an administrative union with the Trust Territory of New Guinea. The Act, which is administered by the Minister of State for Territories, the Honourable Paul Hasluck, M.P., through the Department of Territories at Canberra, provided for the appointment of an Administrator to administer the government of the Territory on behalf of the Government of the Commonwealth of Australia. The Administrator is assisted by an Administrator's Council of six members over which he presides. The Act also provided for a Legislative Council which, subject to the assent of the Administrator or, in certain cases defined in the Act, of the Governor-General, has full legislative powers in regard to the peace, order and good government of the Territory.

Under the general direction of the Administrator the administrative functions of government are discharged by seventeen Departments, the officers of which are members of the Public Service of the Territory of Papua and New Guinea. The detailed administration of each Department is the responsibility of the departmental head, subject to the direction of the Administrator. Head-quarters of the Administration are located in Port Moresby, Papua.

The Territory is divided into fifteen districts, as shown in Figure 1. Each district is under the control of a District Commissioner, who is responsible for the co-ordination of Administration activities in his area.

PHYSICAL

The total area of the Territory of Papua and New Guinea is 183,500 square miles. It lies wholly within the inner tropics between Latitudes 1° and 12° South and Longitudes 141° and 156° East. New Guinea and its associated islands represent the eastern extremity of the great arc of fold mountains which extend through the Himalayas and Malaya into the Pacific. The central cordillera, which is one of the great mountain systems of the world, extends from one end of the mainland to the other, a distance of about 1,500 miles. It reaches heights in excess of 15,000 feet and includes some of the world's most rugged country.

The rainfall is generally moderate to high although strongly monsoonal in many areas, and there are no deserts or very arid zones. Extensive swamps occur in the lowlands. There are major valley systems in the highlands with floors generally around 5,000 feet. These highland valleys have a mild climate with frost occurring at higher altitudes and there is occasional snow on a few of the highest mountain peaks. The climate in the lowlands is typical of the humid tropics.

The physiography, drainage, climate, soils, and agriculture of the Territory were discussed in some detail in the 1959-60 Annual Report.

THE DEVELOPMENT OF COMMERCIAL AGRICULTURE, ANIMAL HUSBANDRY AND FISHERIES IN PAPUA AND NEW GUINEA

While agriculture and fishing have been the primary occupations of the peoples of Papua and New Guinea from pre-historic times, production was predominantly for subsistence with very little commercial exploitation. A certain amount of trading did take place, such as exchange between coastal and inland peoples of dried fish for taro, and trading in shells used for ornament. In New Britain the Tolais of the Gazelle Peninsula had a well-organised system of currency based on " tambu " shells, and this was used for local trading in garden produce. Organised annual expeditions were also made to purchase the tambu shells from the people of the north coast. In Papua the Motuan people of the Port Moresby area made annual trading expeditions to the west and exchanged pottery for sago and canoe logs. Similar trading was also practised in other areas.

Active commercial development came only with the advent of the European trader, and did not reach any magnitude until the annexation of the Territories and their administration by, initially, the German and British Governments. Because of differences between the two administrations, which included differences in agricultural policy, development of the two territories will be considered separately up to the second world war. However, in both territories, equally, development in the early period was primarily under European proprietorship on a plantation system. The reason for this may have been in some part the prevailing attitude of the colonial powers to dependent peoples, but far more important was the indifference of the indigenous peoples towards economic development. They were initially quite content with their subsistence farming and undertook only a limited amount of trading or labouring in order to obtain a few luxury goods. It was only through observation of the success of commercial plantations and the material prosperity of foreign peoples (especially as seen during the second world war), that incentive was gained for concentrated efforts at production.

NEW GUINEA

The first established settlement was made by a German trading company in 1873 on the Gazelle Peninsula of New Britain. Two stations were established to trade for copra through the islands area. In the following decade some plantation activity commenced, and this became organised with the establishment of the German New Guinea Company in 1884. In the same year the area comprising the present Trust Territory of New Guinea was annexed by the German Government.

Copra was the first item of trade, and coconuts continued to be, and remain to the present day, the mainstay of agricultural development. By the turn of the century coconut planting was active in both New Britain and New Ireland and to a lesser extent on the mainland. In the early plantings, cotton was used extensively as a catch crop between palm rows. Coffee, cacao, kapok, pepper, rubber and tobacco were all being tried out in 1902. During the following few years sisal was grown on a scale reaching two or three hundred acres, but it did not prove very profitable and by 1910 the area planted was declining. Of the crops tried only rubber and cacao expanded on any scale in the first decade of the century. Rubber plantings up to 1905 were predominantly of *Ficus elastica* with small areas of *Castilla*. By 1905 it had emerged that *Hevea brasiliensis* was a better yielder and attention turned to this species. However, seed was scarce and rubber prices falling, and by 1911 rubber planting had virtually ceased. The area in 1914 was reported as greater than 5,000 acres of which 3,300 was in bearing, but exports amounted to only 20 tons. *Hevea* was also tried as a shade tree for cacao, but apparently was not successful. Area of cacao itself had reached about 1,000 acres by 1911 and 40 tons of cocoa beans were produced in that year, but plantings were not well established by the outbreak of war and during the war years most of the area was lost.

German interest in development was intense, and by 1913 some 450,000 acres of land had been reserved for coconut planting, with about 80,000 acres already planted. It was stated that there was ample capital available for expansion and the main limiting factor was the availability of land for alienation in areas under Government control.

Livestock numbers by 1911 amounted to 1,866 cattle and 434 sheep. Jersey and Guernsey cattle were introduced and a breeding station was established at Kieta, Bougainville, but milk yield was very low.

Extension work amongst the native peoples included introduction of new food plants and encouragement to produce copra. Prohibitions were made of selling whole coconuts to traders to encourage villagers to cure the copra themselves.

With the outbreak of war in 1914 the Australian Government took possession of New Guinea and placed it under military control. During the war

years the planters continued to produce copra but were not able to remit the profits to Germany. Thus they devoted their attention to extending their plantings, in anticipation of compensation based on the numbers of palms planted. While the result of this was of great benefit in the extension of plantations, some planting was done on unsuitable areas.

After the war, in 1921, the Territory was placed under civilian administration by Australia under mandate from the League of Nations. The German plantations were expropriated and were subsequently sold by tender, mostly to ex-servicemen. The price paid was based on the current value of production, and as copra prices declined steadily over the following decade many of the purchasers found themselves in financial difficulties. Naturally enough, the rapid expansion phase ceased, although from about 1926 onwards the planted acreage resumed a steady increase.

The role of copra in the economy may be seen from Table 1 which shows copra prices and the value of copra exports as a percentage of total exports at intervals from 1913 to 1940. The relative decline in importance in the 30's was a combined result of falling copra prices and an enormous increase in the value of gold exports.

TABLE 1. COPRA PRICES AND RELATIVE VALUE OF COPRA EXPORTS 1913–1940

Year	*Copra Value as Percentage of Value of all Exports*	*Average Price per Ton*
		£ *s.* *d.*
1913 ..	77	21 12 9
1919–20 ..	88	32 16 3
1924–25 ..	95	20 19 10
1929–30 ..	87	13 10 10
1934–35 ..	15	6 8 6
1939–40 ..	14	8 10 0

Falling copra prices, which reached bottom in 1933-34 at £4 11s. per ton, also had an adverse influence on efforts to encourage the Native peoples to increase their production. As prices fell so their interest declined. The result was that, while the area of bearing palms on plantations steadily increased, production and export of copra remained fairly static because less trade copra was offered. It was only after prices began to improve in 1935 that exports increased and a peak of 76,000 tons was attained in 1936-37 when prices rose to £16 2s. 4d. per ton.

Other developments in the coconut industry were the establishment of desiccated coconut factories and a coir fibre mill. The latter produced only a small output which was utilised locally. Desiccated coconut production commenced in 1929 and exports rose rapidly to 1,300 tons in 1931-32, thereafter gradually increasing to a maximum of 1,781 tons in 1939-40.

There were also developments in field practice. Planting of cover crops to control weeds was greatly extended, though it is surprising to find that at least one of the species used for this purpose initially was *Passiflora foetida,* now regarded as a more or less serious weed. In the twenties, leguminous cover crops were coming into use, and their area was greatly extended in the thirties. *Centrosema, Calopogonium* and *Pueraria* were the most popular. Interplanting of cacao under coconuts reached quite an extensive scale by the late thirties and the area interplanted was reported to be 3,300 acres.

Livestock also were primarily an adjunct of the coconut industry, as they were run on plantations, where they reduced maintenance costs by controlling the ground cover and provided a proportion of the rations for the labourers. Most herds had a proportion of Zebu blood. Horses, mules, bullocks and water buffalo were in use as draught animals. Goats and sheep (" hairy " or Javanese type) were run on plantations for the same purpose as cattle.

Full statistics of livestock numbers are not available, but in 1929 there were 13,757 cattle (of which 1,419 were classed as working cattle) and numbers increased steadily to a maximum of 20,494 by 1940. Sheep numbers during this period ranged between 1,100 and 2,200 and goats increased from 6,400 in 1929 to 9,300 in 1940. Horse numbers were fairly stable through the 30's at about 900 to 1,000.

No other plantation products attained much prominence in the between-wars period. The cacao industry stagnated from 1914 to 1921 and thereafter declined, but interest began to revive about 1928. It was not until 1937 that there was any substantial increase in production. Rubber production ceased entirely between 1921 (when 29 tons were produced) and 1938, when favourable prices led to tapping of some of the old surviving stands. Production was 119 tons in 1939-40 and 146 tons in 1941-42. Planting of coffee (almost entirely Robusta, in the lowlands) increased in the thirties and by 1940 about 2,000 acres were reported as in bearing. Production for the same year was only 48 tons, so the industry was hardly thriving. Several hundred acres of kapok were planted, but production never amounted to much and all was utilised locally. Peanuts, rice and tobacco were produced from time to time. Oil palms were introduced and small plantings were made, but they never attained commercial production

Plate 1. Cattle grazing in a Papuan coconut plantation. (*Photo: A. E. Charles*)

Marine products were not prominent in commerce, but coastal plantations secured considerable quantities of fresh fish for labour rations. Fisheries exports comprised mainly bêche-de-mer and shell, amounting to around 400 tons annually, worth one to two per cent. of total export earnings.

Activities of the Department of Agriculture increased during the period. The German Administration established botanical gardens at Rabaul and these were maintained and extended by the Australians. They were used for introduction, multiplication and testing of economic plants as well as ornamentals, and served as headquarters for the Agriculture Department. Entomological services were provided from the twenties, and attention was given to biological control of coconut pests, especially *Sexava*. An economic botanist was appointed in 1935 and he initiated valuable field experiments and breeding programmes, as well as studying agronomic and disease problems in the field. An agricultural chemist was appointed in 1940, but had little time to establish his work. Small field stations were run for a few years in the twenties. One at Lae was primarily concerned with growing food for roadworkers and another at Wau was also established primarily to grow food, but is notable as the point of introduction from Jamaica of " Blue Mountain " Arabica coffee, the variety now widely grown in the Highlands. A third station at Sangan in the Markham Valley was used for unsuccessful cotton growing trials and also successfully as an extension centre to introduce peanut cultivation to local people. The permanent experiment station at Keravat, New Britain, was established in 1928, and continually expanded, with plant introductions, demonstrations, experiments and breeding material. Between 1936 and 1938, demonstration stations were established at Aiyura, Madang and Bainyik.

Extension work was performed by a number of inspector-instructors who visited plantations and villages to give advice. Copra inspection was instituted in 1929. An agriculture training school for Natives was established at Keravat in 1929, but functioned for only a few years. Publication of a quarterly journal, *The New Guinea Agricultural Gazette*, commenced in 1935.

This period of development ended in 1942 with the invasion of the Territory by Japanese armed forces. Commercial agriculture ceased until 1946, and during the war years a large proportion of plantation areas was destroyed or damaged, and the livestock population was almost completely killed.

PAPUA

Papua was proclaimed a British Protectorate in 1884, and was annexed as British New Guinea in 1888. From then until it passed to the Australian Commonwealth in 1906 the Territory was under the joint control of the British and Queensland Governments. Up till 1900 there was no clear Government policy on land and very little planting took place. Apart from a few small areas of coconuts, the main planting prior to 1900 was of Arabica coffee at an elevation of 2,600 feet about 20 miles from Port Moresby.

There was some exploitation of existing resources, and the major items of export up to the turn of the century were copra, bêche-de-mer, pearl shell, sandalwood and rubber. Of these items, bêche-de-mer and pearl shell, with other shells and pearls, continued at about the same export level for many years, and thus became progressively less important as other industries developed. Sandalwood was a relatively important item (at times the most valuable single item) of trade up till 1910, but by then the accessible stands were virtually cut out. Rubber in this period was collected entirely from indigenous plants, including *Ficus* species and vines.

The Administration proceeded to acquire land from the Papuans where it was considered to be surplus to their present or foreseeable future requirements. In 1906 a Land Ordinance was promulgated under which the Crown retained the sole right of acquiring land from the Papuans, and leases could be granted to settlers at very low rentals for periods up to 99 years. Provision was made for the cancellation of leases within five years if reasonable efforts had not been made to improve the land. Land was advertised in both Australia and Britain and great interest was aroused. By 1911, a total of 364,000 acres had been leased, but a proportion of leases were only speculative and many were forfeited. Thus, although new land continued to be taken up, the total area leased declined and by 1914 had dropped back to 231,000 acres.

As in New Guinea, the main development was in coconut planting, but this crop was not so completely dominant as in the German Territory. Nevertheless copra very soon became the largest agricultural export and was second in value to gold, which at the time was the mainstay of the economy. By 1916-17 gold production was declining and gold was overtaken in value by copra, which thereafter held first place amongst all exports. As in New Guinea, a desiccated coconut industry commenced in 1929, and an annual production of between 1,100 and 1,800 tons was maintained until the outbreak of war.

Rubber was the second most important crop planted, and fortunately *Hevea brasiliensis* was selected from the outset. Planters were not so fortunate with prices, which declined consistently from the time plantations came into production, and when they were reaching their maximum yield in 1921 to 1923 prices were so low that it was simply not economic to tap the trees. This, following relative stagnation of the economy during the war years, must have had a depressing influence on expansion for many years after, and in the 30's prices again fell to rock bottom.

Sisal hemp was relatively important for a period of about 15 years. It was grown in the dry areas of central Papua and attained an area of about 6,000 acres in 1920, but thereafter declined because of unsatisfactory prices, resulting largely from the heavy shipping freight on a bulky product. Exports fluctuated widely, and apparently the crop was harvested only when markets were favourable. The highest annual export was 447 tons in 1915-16, and the average from 1915 to 1919 was 350 tons. A total of 620 tons was exported between 1923 and 1926 and thereafter the industry ceased.

Unfavourable prices for copra and rubber led to trials of annual crops, and cotton, tobacco and rice all had their day, but were never sufficiently reliable to become permanent. Cotton reached a peak of about 1,500 acres in 1925-26. The early plantings of Arabica coffee could not have fulfilled their first promise, as no more than a few tons were ever produced. Interest turned to Robusta coffee in the thirties and production reached 111 tons in 1938-39.

As in New Guinea, livestock were run mainly on plantations, and cattle numbers increased steadily from about 1,100 at the end of the first war to a peak of 8,500 in 1938. Goat numbers ranged between 1,000 and 2,500.

A Department of Agriculture was formed in 1907 and rendered considerable assistance in the early stages of development by the introduction and testing of a wide variety of economic plants and the establishment of nurseries for the supply of planting material. Many thousands of rubber plants were raised in the nurseries and sold to planters, while tens of thousands of rubber seeds were imported and sold direct to plantations. The numbers of sisal bulbils distributed ran into more than a million. The nurseries functioned for a number of years but were closed down during the first war when staff was short and it was felt that they had fulfilled their primary developmental purpose. An entomologist was appointed in 1911 and engaged mainly in inspection and advisory work on plantation pest control. A stud horse farm was established near

Port Moresby in 1910, but was not a success and was closed in 1916. A coconut and a rubber plantation were commenced in 1911 and after the war they appear to have comprised a fair proportion of Departmental activity. Although they were intended as demonstration plantations their prime function was to augment Governmental finances.

Development of agriculture amongst the indigenous peoples in Papua was under the control of Native Affairs officials rather than the Department of Agriculture. From as early as 1894 encouragement to agricultural production took the form of legislation to permit magistrates to enforce planting in villages, primarily of coconuts. There was found to be a high wastage in seedlings planted and in 1914 the legislation was revised so as to organise plantings as compact village plantations belonging to, and for the benefit of, the village people as a whole. In 1919, further revision was coupled with a taxation ordinance, whereby the people could alternatively pay tax in cash or in work in village plantations. These plantations were now under direct Government supervision and half the profits went into a special fund which could be drawn on only for work associated directly with native welfare. From 1925, the scope of plantations was broadened to cover crops such as rubber, rice and coffee as well as coconuts, and in the thirties fairly extensive plantings were made of Robusta coffee in the Popondetta area and rice in the Mekeo area.

On the whole, development in Papua did not keep pace with that in New Guinea. The cause may be traced largely to the few years' lag in the start of planting in Papua, whereby New Guinea plantations were better established before prices fell, and to the different effect of the war on the two territories. In New Guinea, the war caused planters to be confined to their plantations with nothing to do but go on planting, whereas in Papua a third of the expatriate men enlisted and general disruption of services caused stagnation of planting activity. Thus at the end of the war New Guinea had a solid foundation of productive plantations which were able to go on expanding despite depressed prices, whereas Papuan plantations were struggling to survive. This was especially true of the rubber plantations.

With the outbreak of war in 1939, problems arose in shipping produce and in 1942 the invasion of New Guinea and parts of Papua led to transfer of administration to military control. While creating problems in the shipping of produce, the war rendered this produce (especially rubber) of increased importance to Australia and the Commonwealth Government established a Production Control Board which handled marketing and shipping during the war and the subsequent period of reconstruction. As a result, on the Papuan plantations still able to operate, production continued at a fairly high level.

PAPUA AND NEW GUINEA AFTER 1945

Up till about 1955 the major effort in agriculture, particularly in New Guinea, was directed at rehabilitation of pre-war plantings. Since then there has been a rapid expansion of new development.

Amongst the most notable developments of the period have been the opening up of the Highlands, rapid expansion of the cocoa and coffee industries, steady increases in the existing coconut and rubber industries, and a steady development of livestock raising as an industry in its own right rather than simply an adjunct to coconut culture. In all these things there has been a large expansion of indigenous participation. This may be attributed to considerably increased activity of the Department of Agriculture, Stock and Fisheries, especially in the field of Extension and training work amongst the Native peoples. The combined expatriate staff for both territories numbered only about 35 in 1941, while by 1963 staff has grown to 330 of which a large proportion are field Extension officers.

No further detail will be given here, as the remainder of this Report, with its predecessors, gives a full review of postwar developments at the stage reached after fifteen to eighteen years. A statistical summary of the growth of the major agricultural industries is presented in Table 2 and Table 3.

TABLE 2. AREAS PLANTED TO COCONUTS AND RUBBER IN PAPUA AND NEW GUINEA 1909 TO 1962 (HUNDREDS OF ACRES)

Year	*Coconuts*			*Rubber*	
	Papua	*New Guinea*	*Total*	*Papua*	*New Guinea*
1909 ..	67	395	462	19	n.a.
1914 ..	290	777	1,067	66	56
1919 ..	436	1,340	1,776	86	n.a.
1924 ..	468	1,723	2,191	75	30
1929 ..	484	1,924	2,408	88	27
1934 ..	479	2,133	2,612	90	n.a.
1939 ..	442	2,554	2,996	128	30
1944 ..	n.a.	n.a.	n.a.	n.a.	..
1949 ..	n.a.	n.a.	n.a.	n.a.	..
1954 ..	343	2,006	2,349	267	..
1959 ..	301	2,057	2,358	267	..
1962 ..	355	2,258	2,613	311	n.a.

TABLE 3. EXPORTS OF PRINCIPAL PRODUCTS, 1911 TO 1960

APPROXIMATE AVERAGE EXPORTS OVER 5 YEAR PERIODS FOR COCONUT PRODUCTS (EXPRESSED AS COPRA EQUIVALENT), RUBBER AND COCOA

Period	Copra ('000 tons)			Rubber (tons)	Cocoa (tons)
	Papua	New Guinea	Total	Papua and New Guinea	Papua and New Guinea
1911–15 ..	1	12	13	15	120
1916–20 ..	2	17	19	140	145
1921–25 ..	6	32	38	240	115
1926–30 ..	12	57	69	690	82
1931–35 ..	10	61	71	913	86
1936–40 ..	12	72	84	1,294	199
1941–45 ..	6	16	22	1,178	137
1946–50 ..	8	23	31	1,208	117
1951–55 ..	14	73	87	2,890	643
1956–60 ..	15	84	99	4,159	3,175

CURRENT TRENDS IN PRODUCTION

As in the past, agriculture continues to be the main economic activity in Papua and New Guinea. Not only does subsistence farming provide the majority of the indigenous people with their basic living needs, but cash crops, (which are in reality only a small part of total agricultural production), are a most important source of export income.

Furthermore, the economic development of the Territory is primarily dependent on progress in the agricultural sector and the Department of Agriculture, Stock and Fisheries, aware of this challenging situation, has continued to work and plan for maximum economic and agricultural progress.

During 1963 the "Survey of Indigenous Agriculture 1961-62" was published by the Statistician. This study has provided a much needed set of basic statistics on indigenous agriculture, both subsistence and cash cropping. Further information on this Survey is presented under *Division of Extension and Marketing.*

Apart from relatively small quantities of truck crops and animal products marketed in the main centres, virtually all commerical production is exported. Export figures therefore give a fairly exact index of commercial production.

AGRICULTURAL EXPORTS

During the two years under review agricultural commodities continued to dominate the export picture, as shown in Table 4.

TABLE 4. VALUE OF PRINCIPAL EXPORTS[1] AS A PERCENTAGE OF TOTAL EXPORT INCOME IN SELECTED YEARS

Commodity	1952–53		1958–59		1959–60		1960–61		1961–62		1962–63	
	£'000	Per Cent.	£'000	Per Cent.	£'000	Per Cent.	£'000	Per Cent.	£'000	Per Cent.	£'000	Per Cent.
Coconut Products—												
Desiccated Coconut ..	330		0		0		0		0		0	
Copra	6,245	68	5,754	60	6,126	60	5,113	54	4,610	48	4,718	45
Coconut Oil ..	473		2,754		3,814		2,361		1,969		2,334	
Copra Cake and Meal..	36		179		346		284		260		329	
Rubber (including Scrap)	736	7	1,152	8	1,500	9	1,292	9	1,211	8	1,174	7
Cocoa	175	2	1,492	10	1,671	10	1,666	12	1,983	14	2,956	18
Coffee	31	..	456	3	717	4	1,106	8	1,557	11	2,014	12
Peanuts	21	..	297	2	284	2	280	2	305	2	296	2
Total Agriculture[2]	8,047	77	12,084	83	14,458	85	12,102	85	11,895	83	13,821	84
Shell—												
Green Snail	42		10		13		8		10		3	
Mother of Pearl ..	16	1	2	1	4*	1	2	..	8	..	3	..
Trochus	71		82		93		44		38		23	
Other Non-agricultural[3] ..	2,297	22	2,290	16	2,536*	14	2,101	15	2,371	17	2,519	16
Total ..	10,473	100	14,468	100	17,104	100	14,257	100	14,322	100	16,369	100

[1] Excludes re-exports (Not "includes", as was stated in the 1960–61 Annual Report) [2] Excludes passionfruit pulp and juice [3] Includes gold

* *Note.*—The figures marked with an asterisk have been changed from those published in the 1960–61 Annual Report.

Source of Information: Oversea Trade Bulletins Nos. 1–8 inclusive.

Table 4 shows that 83 per cent. and 84 per cent. of total export earnings came from agricultural commodities during 1961-62 and 1962-63, respectively. It is interesting to note that their relative importance has not varied appreciably throughout the last five years.

Rapid progress is being made towards diversity of agriculture in the Territory. Coconut products have remained the principal export for many years, but they now contribute a smaller proportion of export income. Cocoa is the second most important agricultural export and the proportion of export income derived from this source has increased considerably over recent years. Coffee has also increased its share of export income. Owing to falling prices rubber now ranks fourth in importance and is only just maintaining its proportion of export income.

Table 5 shows the quantities of the principal exports for the selected years.

Coconut Products

The values of coconut products exported are shown in Table 4 and Figure 2, and quantities are shown in Table 5 and Figure 3.

Coconut products which in 1952-53 generated 68 per cent. of total export income realised only 45 per cent. of total export income in 1962-63. Desiccated coconut, which in 1952-53 provided 3 per cent. of total export income, is no longer produced in the Territory, mainly owing to the difficulty in meeting health regulations in Australia, the principal market. Copra's share of total export income has declined from 60 per cent. in 1942-53 to 29 per cent. in 1962-63. Coconut oil and copra meal which are produced at a copra crushing mill in Rabaul, established in 1953, now account for 14 per cent. and 2 per cent. of total export income respectively. In 1952-53 export income from these two commodities was only 5 per cent. of total export income.

Copra exports amounted to 72,499 tons in 1962-63 compared with 76,392 tons during 1952-53. This represents a decrease in copra exports of some 3,893 tons. However, production of copra actually increased over the decade and the decline in exports resulted from an increase in local crushing. Exports of coconut oil increased from 3,568 tons in 1952-53 to 23,641 tons in 1962-63. Copra meal exports which were 2,085 tons in 1952-53 increased to 12,749 tons by 1962-63.

Average annual export values for copra, which had reached a peak in 1959-60 at £93.7 per ton declined to £61.6 per ton in 1961-62 but rose slightly to £65.1 per ton in 1962-63. Consequently the value of copra exports was at its lowest point for the five year period (1958-59 to 1962-63), in 1961-62 when the value of copra exports was only £4,610,000. Owing to the improvement in world copra prices during 1962-63 the value of copra exports (despite the decrease in tonnage) rose slightly to £4,718,000.

Coconut oil average annual export values continued to fall from £149.4 per ton in 1959-60 to £98.7 per ton in 1962-63. The average annual export value of copra meal followed a similar course to that taken by copra, falling from £28.2 per ton in 1959-60 to £22.7 per ton in 1961-62 but rising to £25.8 per ton in 1962-63.

Some 26 per cent. of total copra production was produced by the indigenous people during 1962-63.

Over the three-year period 1960-61 to 1962-63, all coconut oil and copra meal and an average of 79 per cent. of all copra exports were shipped from the Territory of New Guinea.

TABLE 5. QUANTITIES OF PRINCIPAL EXPORTS (IN TONS) IN SELECTED YEARS

Commodity	*1952–53*	*1958–59*	*1959–60*	*1960–61*	*1961–62*	*1962–63*
Coconut Products—						
Desiccated Coconut	1,377	0	0	0	0	0
Copra	76,392	64,009	65,396	76,524	74,839	72,499
Coconut Oil	3,568	21,541	25,526	20,429	19,627	23,641
Copra Cake and Meal	2,085	7,947	12,269	10,290	11,506	12,749
Rubber (including Scrap)	2,911	4,380	4,399	4,373	4,680	4,760
Cocoa Beans	639	4,253	5,870	7,291	10,014	14,071
Coffee Beans	47	969	1,488	2,294	3,444	4,845
Peanuts	110	1,766	1,897	2,019	2,212	2,064
Shell—						
Green Snail	259	30	33	17	24	11
Mother of Pearl	32	12	14	5	31	10
Trochus	505	252	342	239	242	207

Source of Information: Oversea Trade Bulletins Nos. 1–8 inclusive.

Cocoa

Values of cocoa exports are shown in Table 4 and Figure 2, and quantities are shown in Table 5 and Figure 4.

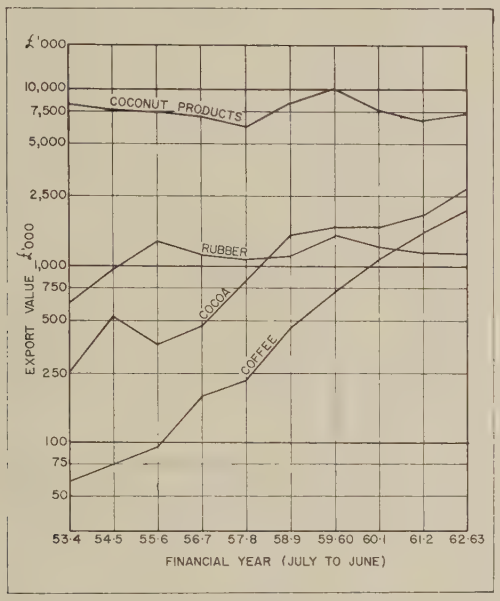

Figure 2: Values of exports of major agricultural products, 1953-1963 (vertical scale logarithmic).

Cocoa is the second most valuable agricultural export and in 1962-63 generated 18 per cent. of total export income. This can be compared with 1952-53 when cocoa exports were responsible for only 2 per cent. of total export income.

Cocoa exports amounted to 14,071 tons in 1962-63 compared with 639 tons in 1952-53, being an increase of 13,432 tons over the decade.

The average annual export value of cocoa which was £350.7 per ton in 1958-59 fell to £196.0 per ton in 1961-62 but rose slightly to £205.3 per ton in 1962-63. However, as production rose steadily during the period, total export income continued to rise, despite the fall in price. Total export income from cocoa rose from £1,492,000 in 1958-59 to £2,956,000 in 1962-63.

Some 26 per cent. of total cocoa production was produced by the indigenous people during 1962-63.

Over the three year period 1960-61 to 1962-63, an average of 99 per cent of all cocoa exports were shipped from the Territory of New Guinea. New areas of cocoa plantings on the volcanic soils of Northern Papua should change this picture in the near future.

Coffee

Values of coffee exports are shown in Table 4 and Figure 2, and quantities are shown in Table 5 and Figure 4.

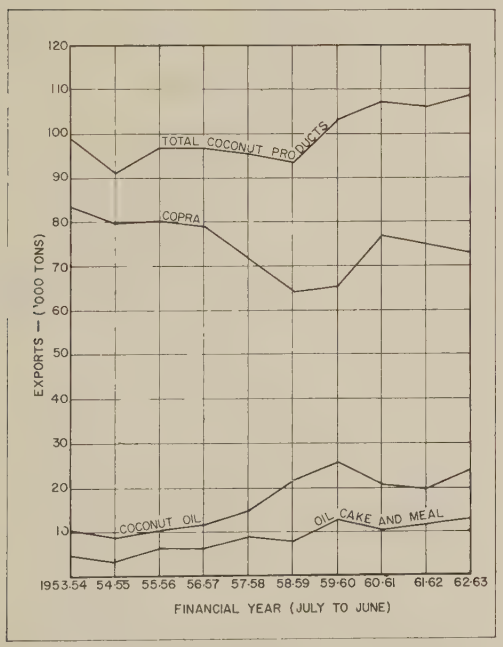

Figure 3: Quantities of exports of coconut products, 1953-1963.

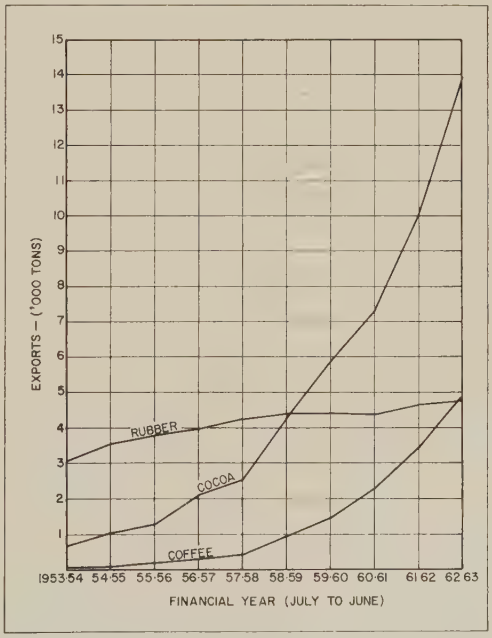

Figure 4: Quantities of exports of cocoa beans, coffee beans and rubber, 1953-1963.

In 1962-63 exports of coffee beans were responsible for generating 12 per cent. of total export income. This can be compared with 1952-53 when coffee exports were responsible for only a negligible proportion of total export income. This increased importance of coffee results from the opening up of the Eastern and Western Highlands for the cultivation of arabica coffee.

Coffee exports amounted to 4,845 tons in 1962-63 compared with 47 tons in 1952-53, an increase of 4,798 tons over the decade. Practically all coffee exported is arabica with some small parcels of robusta.

The average annual export value of coffee rose from £470.6 per ton in 1958-59 to £482.1 per ton in 1960-61 but declined to £420.0 per ton in 1962-63. Increasing production has offset the falling price, and total export income from coffee rose from £456,000 in 1958-59 to £2,014,000 in 1962-63.

Some 45.7 per cent of total coffee production was produced by the indigenous people during 1962-63.

Over the three year period 1960-61 to 1962-63, an average of 99 per cent. of all coffee exports were shipped from the Territory of New Guinea.

Rubber

Values of rubber exports are shown in Table 4 and Figure 2, and quantities are shown in Table 5 and Figure 4.

Rubber, which in 1952-53 was the second most important agricultural export, has now fallen back to fourth place. In both 1952-53 and 1962-63 rubber generated 7 per cent. of total export income.

Rubber exports (including scrap) amounted to 4,760 tons in 1962-63 compared with 2,911 tons in 1952-53, an increase of 1,849 tons over the decade. Newly planted, high yielding clonal rubber will further increase the tonnage available for export in the future.

The average annual export value of rubber which was £262.9 per ton in 1958-59 rose to £341.0 per ton in 1959-60 but since that time has declined until in 1962-63 it was only £252.0 per ton. Although production has increased over the period the total export income from rubber has declined from £1,500,000 in 1959-60 to £1,174,000 in 1962-63.

Some 0.6 per cent. of total rubber production was produced by the indigenous people during 1962-63.

Until 1960-61 all rubber was exported from Papua. In 1961-62, old rubber trees on a Bougainville plantation were tapped for the first time since the war, and some planting of rubber in the New Guinea Islands was commenced in 1962-63.

Over the three year period 1960-61 to 1962-63, an average of only 0.4 per cent. of all rubber exports were shipped from the Territory of New Guinea.

Other Agricultural Exports

The other principal agricultural commodities exported from the Territory are peanuts and passionfruit pulp and juice. Exports of the former amounted to 2,064 tons in 1962-63, and were valued at £296,000. The average export value rose slightly in 1962-63 to £143.4 per ton compared with £138.0 per ton in 1961-62.

Passionfruit pulp and juice shipments during 1962-63 reached 229,995 lb. valued at £41,974. Exports were well below those of the previous year when the total was 492,917 lb. valued at £89,002.

FISHERIES EXPORTS

No significant quantities of edible marine products are exported from the Territory as production is consumed internally. Shipments of shell and crocodile skins occur each year.

Three main types of shell are exported from the Territory, viz., trochus, green snail, and pearl shell. Their values are shown in Table 4. There is a falling world demand for these products because of development of synthetic substitutes.

Trochus

In the period from 1952-53 to 1955-56 there was a strong demand for trochus shell, but since 1955-56 world prices have declined and exports of trochus have dwindled. In 1962-63 exports amounted to 207 tons valued at £22,803 while corresponding figures were 242 tons valued at £38,439 in the previous year.

Green Snail Shell

From 1952-53 to 1955-56 exports of green snail shell remained at about 200 tons, but owing to increasing world prices, values increased to £80,000 in 1955-56. Since that year, however, output has fallen, declining in 1962-63 to 11 tons valued at £3,214. Corresponding figures were 24 tons valued at £9,726 in 1961-62.

Pearl Shell

Exports of pearl shell have remained small throughout the last decade. Value in 1962-63 was £3,182 compared with £7,910 in 1961-62. Ten tons were

exported in 1962-63 compared with 31 tons in 1961-62. The pearl oyster beds of the Territory are not particularly suitable for commercial fishing as they have a sharply shelving bottom and are susceptible to strong tidal influence.

Crocodile Skins

The export value of crocodile skins rose sharply during 1962-63, reaching £344,332, compared with £250,569 in the previous year. The principal hunting areas were the two largest rivers, the Fly and the Sepik, and their tributaries.

INTERNATIONAL COFFEE AGREEMENT

The director of the Department, accompanied by the President of the Highland Farmers & Settlers' Association, Mr. I. F. G. Downs, was a member of the Australian delegation to the meeting of the International Coffee Study Group held in Washington in March 1962, the delegation being led by Mr. G. J. Hall, Commercial Counsellor at the Australian Embassy in Washington.

Subsequently the Chief of the Division of Extension and Marketing participated as alternate delegate to Mr. Hall in the International Coffee Conference held at the Headquarters of the United Nations in New York in July-August 1962. As a result of these meetings, an International Coffee Agreement was negotiated which has subsequently been ratified by all important producers and consumers of coffee and is now in operation. Australia has joined the Agreement and, in accordance with Articles which provide specially for this purpose, has extended the Agreement to Papua and New Guinea, including the Territories within a single membership with herself. It is pleasing to note that the Agreement provides for exports from Papua and New Guinea both to Australia and other countries which will cover the best estimates of all available production in the Territory during the period covered by the Agreement.

COCOA

The Territory has recently been represented in International negotiations aimed at reaching an International Commodity Agreement on Cocoa. The Chief of the Division of Extension and Marketing participated in meetings of the F.A.O. Cocoa Study Group held in Rome in November-December 1962, and in Port-o-Spain, Trinidad in March 1963. At the Rome meeting, the Australian delegation was led by the Australian Trade Commissioner, Mr. P. Donovan, and at the meeting in Port-o-Spain, Mr. G. J. Hall led the delegation which also included Mr. N. Thompson, Executive Officer of the Territory's Department of Trade and Industry. The results of draft agreements arising out of these meetings showed recognition of the Territory's need for export opportunities for its rapidly expanding production and also of the usage of Territory cocoa as a fine or flavour type.

An International Cocoa Conference is to be held at Geneva in September 1963.

DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES

ORGANIZATION

The Department of Agriculture, Stock and Fisheries has its head-quarters at Port Moresby under the direct control of the Director, operating through the Administrative Officer, who is in charge of the administrative and clerical section, and the Chiefs of the four technical divisions, which are: the Division of Animal Industry, the Division of Plant Industry, the Division of Extension and Marketing and the Division of Fisheries.

For the purposes of the Department of Agriculture, the Territory of Papua and New Guinea is divided into three regions, namely, Papua, the New Guinea mainland, and the New Guinea islands. A semi-autonomous organization operates in each of these regions under the control of a Regional Agricultural Officer who is responsible for directing the activities of the Division of Extension and Marketing and for co-ordinating the activities of the other Divisions represented in his region. The Division of Extension and Marketing is the only one represented in all districts, and the District Agricultural Officer and his sub-district staff may be required to carry out agency functions for other Divisions as may be appropriate.

The Division of Animal Industry is responsible for research and services with livestock throughout the Territory. The principal types of livestock are British breeds of cattle or more commonly in the lowlands British breeds with an infusion of Brahman blood, owned mainly by expatriates, and pigs and poultry owned mainly by the indigenous inhabitants. The Division operates Livestock Stations where it carries out research and breeds livestock for distribution. There are supporting laboratories with modern equipment to handle all aspects of parasitology, pathology and bacteriology.

The main functions and activities of the Division are as follows—

(i) The promulgation and administration of animal quarantine legislation.

(ii) The maintenance of quarantine programmes and supervision over internal and external stock movements.

(iii) The provision of clinical and advisory veterinary services to stock owners.

(iv) The planning and conduct of programmes of disease and pest eradication and control.

(v) Investigations on animal pest and disease problems.

(vi) Selection and breeding of stock adapted to Territory environments.

(vii) Services and research in animal husbandry.

The Division of Plant Industry is responsible for research and investigations into all aspects of agriculture and the provision of technical services to the Department and the general public. The specialist sections of the Department of Agriculture, Stock and Fisheries, with the exception of those engaged in livestock research, are attached to the Division of Plant Industry, which also operates Experiment Stations in representative environments throughout the Territory. The main laboratories are in Port Moresby but there are supporting laboratories at selected field stations. The Division is divided into sections each under its own section head.

The main functions and activities of the Division are as follows—

(i) The promulgation and administration of legislation concerned with plant quarantine and the control of pests, diseases and noxious weeds.

(ii) Plant introduction and testing of new crops and new varieties of established economic species.

(iii) Crop improvement and agronomic experiments with all crops grown in the Territory.

(iv) Production of high grade seed and planting material.

(v) Investigation of farming systems.

(vi) Research on crop processing methods.

(vii) Design and operation of model crop processing facilities and testing of new processing machinery.

(viii) Soil and land use surveys.

(ix) Research and services in plant pathology.

(x) Research and services in economic entomology.

(xi) Chemical and biochemical services and research.

The Division of Extension and Marketing is responsible for extending to producers, both expatriate and indigenous, the results of investigations carried out by the other Divisions of the Department, and for assisting these producers to apply better techniques to the production, processing and marketing of their crops. The Division also plays a very important role in stimulating and assisting the production of cash crops by indigenous growers who previously had no cash income. Because of the great predominance numerically of indigenous agriculturists, the main emphasis falls on extension and marketing services to this section of the community.

The main function of the Division are as follows—

(i) Agricultural patrolling and village contacts to encourage indigenous landholders to adopt improved methods of production with subsistence and cash crops.

(ii) Distribution of planting material of subsistence and cash crops.

(iii) Agricultural training up to Agricultural College level.

(iv) Maintenance of Extension Stations and Centres for—

(*a*) training of lower level intermediaries;

(*b*) demonstration of crop husbandry and processing techniques;

(*c*) local experimentation and adaptability trials;

(*d*) seed production, especially the production of pure seed of crops of local importance.

(v) Promotion of improved types of rural organizations.

(vi) Supervision of processing of economic crops and operation of central processing facilities where required.

(vii) Assistance with the marketing of agricultural produce where satisfactory normal marketing channels are not available.

(viii) Operation of district mechanisation services and area workshops.

(ix) Produce inspection services.

The Division of Fisheries is responsible for all fishery investigations in the Territory. At the developmental stage, its primary functions are the assessment of sea fishery resources and the promotion of commercial fishing together with the investigation of pond fisheries for inland areas. The Division operates a research vessel, engaged primarily in testing potential trawling grounds, and several smaller auxiliary vessels.

The main functions of the Division of Fisheries are as follows—

(i) The promulgation and administration of fisheries legislation.

(ii) The introduction of improved fishing techniques to indigenous fishermen and the distribution of fishing gear.

(iii) The training of fishermen ashore and afloat in all aspects of fishing.

(iv) The encouragement of the indigenous people to organise their activities and increase their consumption and trade in fish.

(v) Investigation of potential fishing grounds and the encouragement of commercial fishing where this does not conflict with subsistence requirements.

(vi) Promotion of fresh water fish production.

(vii) Investigations into economic and marketing aspects of the fishing industry.

(viii) Institution of a fisheries inspection system.

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DIVISION OF ANIMAL INDUSTRY

The Division is divided into two sections.

Veterinary Services

This section provides the technical advisory services to the developing animal industries of the Territory, and carries out disease eradication and control programmes. It operates through Veterinary Officers and Stock Inspectors stationed at main centres throughout the Territory.

Veterinary Research

This section has two sub-sections:

The Veterinary Laboratory: This provides diagnostic laboratory services for the field Veterinary Officers and Stock Inspectors and carries out research into animal disease problems. Its activities considerably increased during the two years.

Animal Husbandry: Included in this sub-section are the livestock stations where breeding and research into cattle and pig husbandry are carried out. There are eight Stations operated by the Division, three in Papua and five in New Guinea.

VETERINARY SERVICES

DISEASE ERADICATION

CATTLE TICK (*BOOPHILUS MICROPLUS*)

The Division has a policy of ultimate eradication of cattle tick from the whole Territory. The following is a summary of the two years' work in the various Districts where eradication has been attempted. Success has been achieved in some areas, but re-infestation has occurred in other Districts. A fuller account of the eradication programme was published in the following paper: J. L. Anderson (1963): Cattle Tick (*Boophilus microplus*)—Its occurrence and attempted eradication in the Territory of Papua and New Guinea. *Papua and New Guinea agric J.* **15**: 91-104.

Central District

The control spraying programme continued in the lowlands areas, and ticks were seen on only two properties. The interval between sprayings was reduced on these properties to eliminate the infestation rapidly.

One property in the Sogeri area became infested in May 1962. An eradication spraying programme had been completed on this property in June 1954. This was the first sighting of cattle tick in the Sogeri area since early 1953. The origin of the outbreak is unknown although an intensive investigation of movements on and off the station was carried out. The outbreak involved 339 cattle and 10 horses.

In outlying areas there are a number of small herds, but at present the dispersal of these herds over difficult terrain prevents the Department from carrying out control measures. Infrequent sprayings are made by owners of the herds.

Morobe District

No outbreaks of cattle tick were recorded in this District, and it would appear that eradication has been succesful. Several importations of cattle were made from tick infested areas of Queensland, and all were subjected to prescribed treatments in Queensland, and again at the quarantine station at Lae. Larval ticks were found on one shipment of cattle after loading and a few infested cattle were removed from a mob prior to loading for the Territory. These two incidents illustrate the necessity to treat all imported cattle with extreme caution.

In the Finschhafen Sub-District, 28 Native owned herds were inspected and found to be tick free. A group of wild cattle is said to exist in the Tsili Tsili area on the lower reaches of the Watut River. These have not been sighted since 1956 and it is not certain that they are still there.

New Britain District

The spraying programme was completed in December 1961 on the property infested in May 1960, and in September 1962 on the second property on which cattle tick were discovered in March 1961. No further outbreaks were sighted. This District has seen regular small re-infestations since eradication was first attempted, indicating that a focus of infestation was remaining adjacent to grazing properties. Deer are present over part of the area, and wild cattle are suspected in one isolated area. This focus may have to be eliminated if eradication is to be permanent.

New Ireland District

Two plantations in the southern part of New Ireland are tick infested, but at present cannot be dealt with because of their isolation. The problem is similar to that with outlying areas in the Central District of Papua.

Manus District

All except one plantation have been inspected and found tick free.

Bougainville District

One herd at Kieta was infested, but the cattle were all slaughtered or sold. It is likely that all herds in this Sub-District are infested. Other herds on the mainland of Bougainville are isolated and have not yet been inspected.

Buka Island cattle inspected were found to be free, and another small herd not closely inspected was thought to be free.

Highlands Districts (Eastern, Western and Southern)

These Districts remained tick free.

Madang District

The spraying programme on three properties and a small group of Native owned cattle was completed in April 1962, and no re-infestations of these or earlier treated properties were recorded. The programme was extended to all herds on Kar-Kar Island. However in an area just south of the eradication area the programme lapsed because of mustering difficulties with semi-wild cattle.

Herds in the Bogia Sub-District are infested, and have been kept in isolation. A thorough inspection of herds south of Bogia towards Madang showed that the infestation did not extend far south of Bogia.

Sepik District

Control work commenced only in December 1962, when a Stock Inspector was appointed to Wewak.

Ticks were present on one property and eradication spraying was commenced, but difficulty was experienced at first in obtaining full musters. Extra stockmen and horses will be brought from Lae to assist. Twenty-three other herds were free, and another remained free after only five months spraying. Wild cattle are present in some areas and are thought to be infested, which will complicate eradication.

Northern District

This District was stocked with clean cattle and has remained free.

Milne Bay District

Several herds on the mainland are infested, but their isolation in difficult country has prevented extension of the programme to them.

In the island groups, with the exception of Sudest Island, most small herds are free of tick.

Western District

One herd on the south bank of the Fly River and a small herd on Daru Island are infested. Two small herds at other centres are free. Cattle tick were recovered from deer shot near the Bensback River.

Table 6 gives a summary of the spraying programmes in progress during the two-year period.

TABLE 6. RESULTS OF CATTLE TICK ERADICATION PROGRAMME

District	*Year*	*No. of Animals Treated*		*Holdings under Treatment*	*Holdings Reinfested*	*Treatments Completed*
		Cattle	*Horses and Donkeys*			
Central	1961–62 ..	2,253	130	8	1	0
	1962–63 ..	**2.570**	**147**	**9**	**1**	**0**
New Britain	1961–62 ..	93	7	2	0	1
	1962–63 ..	**11**	**3**	**1**	**0**	**1**
Madang	1961–62 ..	936	0	4	0	4
	1962–63 ..	**93**	**41**	**9**	**0**	**0**
Sepik	**1962–63 ..**	**172**	**1**	**1**	**0**	**1**

Plate 2. Spray race used in the control of cattle tick and screw-worm fly. (*Photo: D.I.E.S.*)

TABLE 7. TUBERCULOSIS TESTING CAMPAIGN

District	Year	Animals Tested	Reactors	Properties Tested	Properties Affected	Per Cent. Reactors
Central	1961–62 ..	3,023	4	14	3	0.14
	1962–63 ..	**4,112**	**0**	**18**	**0**	**0**
New Britain	1961–62 ..	984	0	7	0	0
	1962–63 ..	**925**	**2(1)**	**17**	**2(1)**	**0.22**
New Ireland	**1962–63 ..**	**202**	**0**	**1(2)**	**0**	**0**
Manus	**1962–63 ..**	**28**	**0**	**3**	**0**	**0**
Sepik	**1962–63 ..**	**396**	**0**	**7**	**0**	**0**
Madang	1961–62 ..	378	0	3	0	0
	1962–63 ..	**3,377**	**2(3)**	**29**	**2**	**0.06**
Morobe	1961–62 ..	5,345	3	27	1	0.06
	1962–63 ..	**7,111**	**1**	**22**	**1**	**0.01**
Highlands	1961–62 ..	605	0	6	0	0
	1962–63 ..	**3,661**	**4(4)**	**77**	**3**	**0.11**
Northern	1961–62 ..	794	0	1	0	0
	1962–63 ..	**972**	**0**	**2**	**0**	**0**
Total	1961–62 ..	11,129	7	58	4	0.06
	1962–63 ..	**20,784**	**9**	**176**	**8**	**0.04**

(1) Includes one doubtful reactor, on a property previously free for several years. It was isolated for retesting. (2) Incomplete.
(3) Includes one N.V.L. (no visible lesion) reaction. (4) All N.V.L. reactions, which laboratory examination did not confirm.

The treatment programme was the same as described in the 1960-61 Annual Report, with a Stock Inspector supervising spraying. The Department provides tickicides, spraying plant and operators, while the cattle owners are responsible for maintenance of adequate handling facilities and provision of complete musters of livestock on the due treatment day.

Of the Territory cattle population of 29,013 at June 1963, 23,985 were tick free and 2,835 were under eradication treatment. The remainder were either infested or unknown.

BOVINE TUBERCULOSIS

Testing was carried out in all areas where Veterinary Officers were stationed, and in several other areas by visiting Veterinary Officers. The results of testing are shown in Table 7.

A reactor was detected in 1961-62 in one herd in the Central District which had been free for five years previously, and in 1962-63 a similar case occurred in a small herd on a New Britain plantation. In both these cases laboratory tests substantiated the diagnosis. There was also in 1962-63 a doubtful reaction by one animal in another New Britain herd which had been free for some years. These cases indicate the need for constant testing if eradication is to be achieved.

The progress of the eradication scheme is summarised in Table 8. The increase in properties infected in 1962-63 was a result of extension of testing to new properties, except for the one case in New Britain described above.

TABLE 8. ANNUAL PROGRESS IN TUBERCULOSIS ERADICATION

Year	Animals Tested	Reactors	Properties Tested	Properties Infected	Per cent. Reactors
1958–59 ..	4,816	3	..	2	0.06
1959–60 ..	9,378	42	74	13	0.45
1960–61 ..	13,058	43	70	10	0.33
1961–62 ..	11,129	7	58	4	0.06
1962–63 ..	20,784	9	176	8	0.04

Results as shown in Tables 7 and 8 indicate good progress in eradication, especially when it is considered that in 1962-63, six of the nine reactors occurred on properties which had not previously been tested, and four of these, in the Highlands, were not substantiated by post mortem or by laboratory tests.

BOVINE BRUCELLOSIS

Further check bleedings were carried out in herds where positive reactors had ceased to occur and many herds not previously tested were tested in 1962-63.

Areas are now classified according to the Brucellosis status of the herds as follows—

1. Brucellosis free areas
2. Brucellosis eradication areas
3. Brucellosis unknown areas

TABLE 9. RESULTS OF BRUCELLOSIS TESTING

District	Year	Sera Tested	Reactors	Properties Tested	Properties Affected	Per cent. Reactors
Central	1961–62	1,091	1	12	1	0.09
	1962–63	**2,834**	**0**	**17**	**0**	**0**
Northern	1961–62	569	0	1	0	0
	1962–63	**5**	**0**	**1**	**0**	**0**
Milne Bay	**1962–63**	**252**	**0**	**5**	**0**	**0**
Highlands	1961–62	92	0	2	0	0
	1962–63	**2,236**	**1**	**66**	**1**	**0.06**
Madang	**1962–63**	**3,631**	**23**	**16**	**2**	**0.63**
Morobe	1961–62	2,675	0	34	0	0
	1962–63	**3,693**	**0**	**28**	**0**	**0**
New Britain	1961–62	671	0	11	0	0
	1962–63	**569**	**0**	**15**	**0**	**0**
New Ireland	**1962–63**	**105**	**0**	**1**[1]	**0**	**0**
Sepik	**1962–63**	**394**	**0**	**18**	**0**	**0**
Total	1961–62	5,098	1	60	1	0.02
	1962–63	**13,719**	**24**	**167**	**3**	**0.18**

[1] Incomplete.

Brucellosis free areas are those in which all herds have given two consecutive complete clean tests at twelve-monthly intervals. In these herds testing is carried out at three-yearly intervals.

Brucellosis eradication areas are those where eradication programmes are in force and contain three classes of herds—

(a) Clean herds are those which have been tested completely without positive reactors, or from which Brucellosis has been eradicated. These herds are tested annually.

(b) Modified clean herds are beef herds of more than 1,000 head in which at least 50 per cent. of adult females and all males are tested annually giving negative results.

(c) Infected herds. These are tested monthly until three complete consecutive clean tests are obtained. If after six months another complete clean test is obtained, the disease is considered to be eradicated from the herd.

Brucellosis unknown areas are those in which herds have not yet been tested.

Results of testing during the two years are shown in Table 9.

Only one positive reactor was diagnosed in 1961-62, but there was also a suspicious reaction from a horse with fistulous withers in the Morobe District. In 1962-63, all but one reactor were in previously untested herds in the Madang District. The Morobe and New Britain Districts, which earlier had some herds with high incidence, were free in both years.

Progress of the campaign over recent years is summarised in Table 10.

TABLE 10. ANNUAL PROGRESS IN BRUCELLOSIS ERADICATION

Year	Sera Tested	Reactors	Properties Tested	Properties Infected	Per cent. Reactors
1958–59	5,704	43	31	5	0.75
1959–60	7,068	68	38	4	0.96
1960–61	8,881	20	51	2	0.23
1961–62	5,098	1	60	1	0.02
1962–63	13,719	24	167	3	0.18

DISEASE CONTROL AND INVESTIGATION

Veterinary Officers and Stock Inspectors provide a constant service for animal desease control and investigation backed by the diagnostic facilities of the Central Veterinary Laboratory. The diseases investigated are reported below according to the type of animal infected.

DISEASES OF CATTLE

Viral

Papillomatosis: Cases occurred sporadically in various Districts, and injuries to the papillomata prove very attractive to the screw worm fly. The most serious infestation was in a herd in eastern Papua where some 25 per cent. of cattle were infected. An autogenous vaccine was prepared for use by the owner, but no results are yet to hand.

Two other diseases, possibly viral in nature, were noted:

Ophthalmia: A condition not responsive to antibiotics, sometimes associated with nasal discharge,

occurred in the Central, Northern, Western Highlands and Morobe Districts. It may be a manifestation of infectious bovine rhino-tracheitis. Material collected from outbreaks will be submitted to the C.S.I.R.O. Laboratory at Parkville, Melbourne, for study.

Ulcerative Condition of the Nasal Cavity: This condition in a cow in a herd in the Papuan Highlands may belong to the mucosal disease complex. Transmission tests supported the theory that it was of viral origin.

Bacterial

Tuberculosis: The position is reported above.

Brucellosis: The position is reported above.

Corynebacterium Infections: C. pyogenes was commonly isolated from abscesses and mastitis. It was also isolated from ear infections, in pure culture from a purulent pneumonia in a calf, and from the uterus of an infertile cow, and was considered to be the cause of one case of bovine abortion.

Haemorrhagic Septicaemia Syndrome: No herd outbreaks of this disease were recorded, but sporadic deaths occurred on five properties in the Central District which had previously had outbreaks. In no instance was *Pasteurella septica* cultured from the cases autopsied. Further discussion of the disease is included below under *Veterinary Research.*

Infectious Keratitis: The disease was diagnosed clinically in the Central, Northern and Morobe Districts, but no laboratory confirmation of the presence of *Moraxella bovis* was made. A severe outbreak occurred on one property in the Northern District following the importation of new stock from Australia. Up to 20 per cent. of the herd was affected.

Listeriosis: An organism identical with *Listeria monocytogenes* except for motility was cultured from a cow in the Central District, but no herd disease was reported.

Necrobacillosis (Calf Diphtheria): This condition was diagnosed in herds in the Morobe District. Treatment with penicillin and streptomycin effected a cure in some cases but deaths did occur.

Mastitis: Dairy herds reported sporadic cases of mastitis. In one case of severe mastitis in the Morobe District *Pseudomonas aeruginosa* was isolated.

Vibriosis: Preliminary serological investigations for the presence of vibriosis were commenced in 1961-62. Two herds in the Central District showed positive reactors, and one suspicious reactor occurred in nine samples from a herd in the Morobe District. Testing for this disease will be extended.

Clostridial Infections: A *Clostridium chauvoei*-like organism was isolated from peripheral blood of an eight months old bull which died suddenly on a property in the Morobe District.

Salmonella Infections: Salmonella group D was isolated from only one of 143 bovine faecal samples, indicating that it is of little consequence in Territory cattle. No *Salmonella* have been isolated from pathological samples.

Actinobacillosis: One case of *Actinobacillus lignierisi* infection was seen in a beast at slaughter.

Colibacillosis: Escherichia coli is often isolated from bovine pathological specimens. Many such isolations are of no significance but pure cultures of the organism isolated from neonatal deaths or calf scours were regarded as significant. It was also isolated from a mastitis case and from pericardial fluid of a cow which suffered a fatal endocarditis.

Streptococcosis: A Group D *Streptococcus* was isolated from an animal which died suddenly in the Morobe District.

Staphylococcosis: One case of *Staphylococcus* mastitis was recorded.

Fungal

Mycotic Dermatitis: Infection by *Dermatophilus* sp. occurred in cattle in the Morobe, Madang, Eastern Highlands and Central Districts. *Dermatophilus dermatonomus* was the usual cause. Three forms appeared—

(i) Hard plaques over neck and shoulders.
(ii) Neonatal form—diffuse roughened areas of skin thrown into folds over the trunk and neck of calves in the first week of life.
(iii) Moist suppurating lesion about 3 in. in diameter.

One steer was successfully treated with sodium iodide in two injections two days apart. The disease is usually treated with copper sulphate washes.

Ringworm: Cases occurred in the Morobe and Highlands Districts, but no organisms have been cultured.

Cryptococcosis: One case of Cryptococcal mastitis occurred on a property in the Morobe District.

Rhinosporidiosis: This was diagnosed in material from a postmortem of a cow from the Lae area.

Nocardiosis: An unidentified *Nocardia* species was isolated from a case of traumatic reticulitis and peritonitis.

Protozoan

Babesiosis: An outbreak of tick fever occurred on a property in the Sepik District after an unsuccessful attempt at cattle tick eradication. The disease was

diagnosed clinically and confirmed on slides from a herd on a plantation in eastern Papua. Forty head were said to have died in the outbreak.

A suspected outbreak in the New Guinea Islands region was not confirmed.

Helminth Infestations

Nematodes: Deaths were caused by hookworm (*Bunostomum phlebotomum*) in herds in two Districts. Its increase in the Sogeri area of the Central District had serious consequences in the performance of young animals. Drenching with "Neguvon" at high dose rates and rotation of pasture controlled the outbreak.

Of interest was the recording of a specimen of *Neoascaris vitulorum* in a calf on one property in the Morobe District. Some of the animals in this herd can be traced back to importations of Zebu cattle from the East Indies before World War I and this may be the source of the infestation.

Poor weaner growth on a property in the Northern District was traced to massive infestations with *Oesophagostomum radiatum*.

Other nematodes were diagnosed in cattle in all Districts and no doubt cause insidious losses from lowered production.

The importance of nematode burdens in the lowering of production in Territory cattle must increase with the steady increase in stocking rates especially in the higher rainfall areas where conditions for the survival of nonparasitic stages of life cycles are very good. Planned drenching and pasture rotation programmes especially for young stock must be instituted to counter the parasite build-up.

Cestodes: Cysticercus tenuicollis was diagnosed from a sheep in the Morobe District and *Monezia* sp. was recorded in cattle in the Central and Northern Districts.

Trematodes: Liver fluke (*Fasciola hepatica*) was recorded in cattle in the Eastern and Western Highlands District and also in the Morobe District. In all cases the fluke were diagnosed in herds that at some time had been run in conjunction with sheep. The parasite was also diagnosed in sheep from the three districts mentioned. Attempts to control the effects of fluke in Departmental cattle herds were made by regular treatment at three monthly intervals of all cattle with hexachloroethane or carbon tetrachloride. On one property the regular treatment has made the fluke much more difficult to find in the livers of slaughtered animals.

Paramphistomum sp. (stomach fluke) occurred in the same Districts.

Arthropod Infestations

Ticks: The position regarding eradication of cattle tick (*Boophilus microplus*) is reported above.

Other ticks recovered from cattle during inspections included *Haemaphysalis novae-guineae, Ixodes confusus* and *Amblyomma* sp.

Buffalo Fly (*Syphona exigua*)*:* This parasite occurs in the Gazelle Peninsula of the New Britain District, on Karkar Island and at Bogia in the Madang District, and on the Western Islands in the Manus District. The Stock Inspector at Rabaul periodically sprays infested herds to reduce the numbers of the flies.

Screw Worm Fly (*Chrysomya bezziana*)*:* Infestations with this parasite continue to be the most serious disease problem facing the cattle industry in the Territory. The pastoral industry in Australia has felt concern over the danger of this fly gaining entry to Australia. Following recommendations of the Biennial Conference of Commonwealth and State Veterinarians held in Canberra in 1961, a preliminary investigation was made in the Territory by Mr. K. R. Norris, Division of Entomology, and Mr. M. D. Murray, Division of Animal Health, of the C.S.I.R.O. This investigation was made to obtain specimen material in order to clarify the identification of species of *Chrysomya* in New Guinea. The fly failed to be attracted by carrion baited traps, but specimens were collected adjacent to wounds on animals. The majority of specimens of *C. bezziana* were recovered by hatching adults from larvae infesting wounds.

In May 1963, the Division was represented at a meeting of the Screw Worm Sub-committee of the Biennial Conference of Veterinarians. The continued concern of Australian quarantine authorities was expressed, and certain extra precautions in examination of animals before movement between different centres in the Territory were requested. The Queensland Department of Agriculture and Stock conducted a survey of animal population and movements in the Torres Strait Islands.

Divisional officers continued to collect larvae from strikes for positive identification and to record location and frequency of strikes and other data, to gain information on the bionomics of the insect.

Two herds surveyed in the Madang District with 207 head and 451 head respectively showed an overall infestation of 2.9 per cent. of struck cattle in each herd. Both herds contained Zebu, Crossbred and British breed cattle. One Santa Gertrudis and one Crossbred animal were struck whilst the remaining 17 were British breeds.

Fly strike is lessened by prophylactic spraying at four to six week intervals using insecticides with long residual effects, and by treatment of wounds

and navels of new born calves with the screw worm smear EQ335.

Bush Fly (*Musca sp.*): A bush fly was said to have caused ocular granuloma in 50 per cent. of a herd in the Milne Bay area.

March Fly (*Tabanus sp.*): was reported as worrying cattle in a herd in the Morobe District.

Plant Poisoning

Cycas circinalis: Posterior limb inco-ordination of varying severity occurs in cattle grazing this plant for a sufficient time. Most owners are aware of this and either attempt to eradicate the plant or prevent access to it by grazing cattle.

A feeding trial using material from *Cycas circinalis* (syn. *media*) near Port Moresby was undertaken at the Veterinary Laboratory. Two steers receiving one and two pounds of *Cycas* a day were used. After eating 170 pounds the steer receiving two pounds daily exhibited clinical signs of poisoning, whilst the other has yet to show any effect.

The United States Institute of Health, Bethesda, Maryland, is studying the condition caused by *Cycas* poisoning. The Division has co-operated by sending various organs and tissues from diseased cattle, together with histories of the cases concerned.

Wedelia spilanthoides (*biflora*): This composite was suspected as the cause of death of a number of cattle at a property in the Markham Valley. To investigate the apparent toxicity of the species, an infusion was prepared in cold water and administered to a steer as a drench at 24 and 48 hours. Following the first dose the steer's respiratory rate and salivation increased. A few minutes after the second dose it died. Autopsy lesions were minimal, being inflammation of the abomasal mucosa and emphysema of the lungs and pleura.

Two steers fed two pounds of the plant daily for eight days showed no ill effects, nor did a horse fed two pounds daily for five days. Possibly only young or flowering stages of the plant are poisonous. Further trials are planned.

Saccharum robustum (*Pit Pit*): This species gave positive reaction in a qualitative test for cyanogenetic glucoside and was the probable cause of death of a young Brahman bull which had grazed on it.

Sorghum almum: Some deaths in the Morobe District were blamed on this species.

Diseases of Uncertain Etiology

Enzootic Haematuria: The haemoglobinuria reported in 1960-61 as a suspected result of ingestion of *Iresine herbstii* was further investigated and diagnosed as enzootic haematuria. Typical haemangiomatous lesions in the bladder, together with decreased haemoglobin and white cell counts, were noted. In Native owned cattle in the Wain and Naba Census Divisions of the Morobe District at least three deaths occurred after some weeks during which condition fell off and haematuria was observed.

Bracken fern was widespread in the grazing areas and, although not positively identified as *Pteridium aquilinum*, the owners were advised to clear it. It is hoped that the problem can be cleared up before the people lose interest in cattle raising.

Hepatic cirrhosis: This condition was seen in two animals in the Northern District, associated with skin lesions on the lower legs. Plant poisoning was suspected.

Prolapsed Prepuce: This was observed in Africander, Brahman and Santa Gertrudis cross bulls. At least three cases were treated surgically in the Morobe District, while others were developing conditions which will require surgery.

Suspected Poisoning: Two cases of sudden death of eighteen month old cattle occurred on a property near Port Moresby. They exhibited marked inflammation of the abomasum and small intestine macroscopically, together with haemorrhagic enteritis, congestion and necrosis of kidneys and congestion of liver and lungs. No bacterial agent could be seen or isolated nor could any known poisonous plant be found in the pasture. One fern, *Gleichenia*, was prevalent in the pasture and was also in the rumen of one beast, so may warrant a feeding trial.

Infertility: This problem, as described in the 1960-61 Annual Report, seems to be serious only on isolated properties rather than being general, as was suggested earlier. Vibriosis testing and field investigations are described in the Veterinary Research section.

HORSE DISEASES

Bacterial

Tetanus: Vaccination of all horses with tetanus toxoid is recommended in all parts of the Territory.

Brucellosis: A suspicious reaction to the agglutination test for *Brucella abortus* was diagnosed from a horse with fistulous withers in the Morobe District. This horse was from a property which was previously infected with bovine brucellosis.

Salmonella paratyphi C. This organism was isolated from faeces of a horse at Rabaul suffering from a diarrhoea refractory to antibiotics. The infection was traced to the stable hand responsible for the horse.

Serological evidence of infection and scouring were present in three horses on another property.

Fungal

Dermatophilus sp.: Lesions in horses at Sogeri resembling mycotic dematitis were reported but the causal organism was not positively identified.

Candida sp.: This organism was cultured from the faeces of a horse.

Helminth Infestations

Nematodes: Habronema muscae, Oxyurus equi, Trichostrongylus equi and *Parascaris equorum* have all been found in horses in the Morobe District. *Strongylus* spp. have been reported at Rabaul.

Cestodes: Anoplocephala perfoliata was recorded in the Territory for the first time in the Morobe District.

Arthropod Infestations

Gastrophilus spp.: G. intestinalis and *G. nasalis* were found, both in large numbers, at autopsy of an imported horse in the Markham Valley. Eggs of this parasite were found on the legs of horses on another property. As the parasite has not been seen in locally bred horses autopsied, it may be worth drenching imported horses before shipment to the Territory.

Chrysomya bezziana: Screw worm strikes were recorded in horses in several districts.

Poisonous Plants

Leucaena glauca: Mimosine poisoning, resulting from ingestion of *L. glauca,* causes a loss of hair from the mane and tail. In severe cases the hooves are affected. Removal of the animal from access to the plant is followed by improvement.

Allergic Conditions

Queensland Itch: is prevalent in most areas. Antihistamines or frequent sprayings with insecticides afford some relief. Treatment of other conditions with Acetylarson, in one case, and Vitamin A injections, in another case, gave relief to attendant Queensland itch. A trial on three affected horses at Lae using Vitamin A injections caused no alleviation of the condition. Further trials with both substances are proposed.

Diseases of Uncertain Etiology

Markham Valley Horse Disease: Little further is known of the etiology of this disease, although several animals died and several possible causes were investigated.

Three cases of this disease occurred on one property in the Markham Valley, resulting in the death of the animals. Two other mild cases were recorded in which treatment with sedatives and tranquilizers may have prevented the fatal consequences. Two horses died suddenly on the same day at a plantation close to Lae. The principal signs in both were bloodstained pericardial and peritoneal fluid, bladder contents bloodstained, fibrinous glomerulitis and necrosis of kidneys. Both horses had been in the paddock for eighteen months with no previous ill-effects.

Two separate cases on another property showed colic symptoms, injected conjunctivae and high pulse rate. One was treated with Glauber's salts and pethidine. It recovered but had a further attack and died three weeks later. Blood stained peritoneal fluid was present, and also aneurism near the ileocaecal valve. The aneurism may have precipitated the attack by interfering with circulation to the area. The other case was treated with paraffin, Glauber's salts, pethidine and carbachol, but died. Visceral peritoneum was congested and haemorrhagic.

Two animals died in a small paddock which contained some well developed isolated patches of the plant *Aeschynomene americana.* Young tips of the plant had been eaten. A C.S.I.R.O. Phytochemical Survey Team which was in the area found that this plant contained an alkaloid, and a methanol extract was made for use in feeding trials. Two test horses were fed 3 lb. and 5 lb. of the plant daily for five days with no apparent effect. A further feeding trial of eight weeks duration was undertaken on the New Guinea Lowlands Livestock Station, Erap, using two part draught horses—a gelding and a mare each of 1,200 lb. live weight. Two pounds of leaves and small branches stripped from freshly pulled plants, together with a bulk of Guinea grass, were fed to each horse daily during this period. Apart from two days of scouring by the mare during which time the *Aeschynomene* was withdrawn, no ill-effects of any nature were noted.

A methanolic extract of the plant prepared by C.S.I.R.O. phytochemists in Lae was fed to guinea pigs at Kila without any ill-effect.

The plant has been reported as poisonous in Central America. It would seem that either it is not poisonous at Erap, or it requires to be eaten in combination with another plant to form or release toxic agents, or it is rendered harmless when pulled and stripped before feeding.

Keratitis: Several horses on a property in the Markham Valley were affected with loss of impairment of sight. Some responded to antibiotics ("chlorocort" ointment or "streptopen" injections) but the manager of the property considers kerosene most useful.

Swamp Cancer: Excessive granulation of wounds is experienced annually on one property in the Central

District. The occurrence coincides with the wet season. Some of the growths have been as large as 7 in. by 12 in. and have involved almost the whole circumference of a leg. The condition is also seen in other parts of the Territory. Cauterization with copper sulphate has been used with some success. Two very severe cases were treated with "Anthiomaline" and both showed remarkable improvement. "Anthiomaline" was given at 20 mg. per 100 lb. body weight intramuscularly every second day. In one case it was used for four weeks.

Deficiency Diseases: A case of osteomalacia was recorded in a horse at Goroka. It would not respond to oral calcium therapy but improved following "calciferol" therapy.

DISEASES OF PIGS

Viral

Papillomatosis: Several deaths resulted from this disease at a piggery in the Morobe District. "Anthiomaline" treatment appears to have eliminated the condition.

Bacterial

Anthrax: The causative organism, *Bacillus anthracis,* is now considered to be identical with that in other countries, and not of lower virulence. During 1961-62, anthrax was confirmed in the Lumi Sub-District of the Sepik District, which may indicate that the disease is more widespread than previously thought. Outbreaks in the Eastern, Western and Southern Highlands were controlled with spore vaccine, and 1,048 pigs were vaccinated in the Lumi area. It is hoped to institute annual vaccinations.

Further details of research on anthrax are given below under *Veterinary Research.*

Brucellosis: Sera from breeding pigs in six herds in the Eastern Highlands, Central Districts, Markham Valley and New Britain District, were tested with negative results.

Corynebacterium equi: This organism was isolated from a submandibular abscess in a slaughtered pig.

Erysipelas: This disease is still confined to one property in the Central District. Further cases in the herd were diagnosed.

Pneumonia: Virus pneumonia of pigs is almost certain to be present in the Territory but it is overshadowed by helminth and bacterial infections in Native-owned pigs which are kept under poor husbandry practices. *Pasteurella septica* and *Corynebacterium pyogenes* have been isolated from pneumonic processes in pigs. Heavy infestations of lungworms *Metastrongylus* spp. are common.

Salmonella infections: A *Salmonella* Group D was isolated from postmortem material taken from a pig which died of a septicaemic infection in the Markham Valley. From a *Salmonella* survey, one Group E isolate was derived from 309 faecal samples and one Group D serotype was isolated from 109 mesenteric lymph nodes cultured, indicating that the incidence of *Salmonella* in Territory pigs is low.

Clostridial infections: Investigation of the etiology of human enteritis necroticans and its relationship to pig feasting is reported below under *Veterinary Research.* A *Clostridium perfringens* Type C variant causes the majority of human cases. As this type has previously been recorded in pigs, samples from pigs in the Highlands were typed. Several carriers of *Cl. perfringens* were found but all were Type A. More comprehensive sampling is planned for the coming year. A strain of *Clostridium perfringens* not yet typed was isolated from a five day old piglet which died. The pathological process was similar to that seen in the human cases of enteritis necroticans.

Staphylococcus aureus was isolated from a case of purulent broncho-pneumonia in a Morobe District piggery.

Klebsiella pneumoniae was isolated from a fatal case of acute mastitis in a sow at Lae.

Fungal

Nocardia sp.: This organism was isolated from peritoneal fluid of some dead piglets. Its significance is not known.

Helminth Infestations

Heavy infestation is usual in Native-owned pigs, resulting in poor productiveness. An increasing awareness by their owners of the importance of internal parasites of pigs was reported in the Morobe District.

Egg counts done at a piggery in the Morobe District were quite high. Although the animals were kept on concrete, nutrition and hygiene were poor. Drenching resulted in considerable improvement.

Stephanurus dentatus (kidney worm) was seen frequently during meat inspection in the Central and New Britain Districts. *Ascaris suum* was also recorded.

Arthropod Infestation

Chrysomya bezziana: Screw worm strikes were recorded in pigs in all districts.

Sarcoptes scabei var. *suis* (Mange mite)was indentified as the cause of an outbreak of mange in a Central District piggery.

Ctenocephalides felis felis (Flea) was found in large numbers in one piggery at Bulolo.

Hemaphysalis novae-guineae and *Ixodes* spp. ticks are often found on pigs in various parts of the Territory.

Haematopinus suis: These lice were collected from pigs in some areas. Treatment with B.H.C. is recommended for control.

Diseases of Uncertain Etiology

Several stillborn piglets were recorded at Administration piggeries. Thyroid glands of some were enlarged while histological evidence of thyroid deficiency was seen in the thyroid gland of another. These piglets were fed mineral salt which should contain sufficient iodine to preclude deficiency, so the salt is being analysed to check whether it does conform to specifications.

Swine Fever in Australia

Following outbreak of swine fever in Australia, a close check has been maintained on piggeries around the main Territory towns, especially those feeding garbage and scraps. Importation of pigs and pigmeats from Australia was prohibited.

Subsequently sera positive to the swine fever neutralisation test were discovered in several parts of Australia where clinical evidence of the disease was not present. Swine sera from the Rabaul and Port Moresby areas were therefore sent to the C.S.I.R.O. Animal Health Laboratory, Parkville, Victoria, for testing. All yielded negative results. Further samples from other areas have been taken but results have not yet been received.

POULTRY DISEASES

Viral

Fowlpox: This disease is endemic throughout the Territory and occurs at all times of the year, with losses occasionally as high as 50 per cent. Vaccination was carried out in some instances.

Encephalomyelitis: Outbreaks were diagnosed on clinical grounds and in one case in imported day old chicks, it was confirmed histopathologically.

Leucosis: Visceral, neural and osteopetrotic forms were diagnosed in adult fowls and visceral and neural form lesions were found in month old chicks which had been imported as day old chicks.

Lymphomatosis: A diagnosis of lymphomatosis was made on post mortem signs and was confirmed histologically.

Bacterial

Botulism (*Clostridium botulinum*)*:* Cases were diagnosed in some Districts. A case in Lae, involving fowls and ducks, was possibly caused by eating dead toads (*Bufo marinus*).

Tuberculosis: Selected flocks in the Morobe District were tested for avian tuberculosis. Several reactors were found, but lesions found in post-mortem examination were indefinite and the organism could not be isolated in the laboratory.

Pullorum (*Salmonella pullorum*)*:* This disease was diagnosed in three flocks in the Morobe District by the whole blood agglutination test. Several reactors had macroscopic lesions and the organism was cultured in the laboratory. In one flock, 7 per cent. reactors were found. Carriers of the organism were found in one flock in the Central District where breeding and hatching were proposed. All reactors were killed and culture in the laboratory confirmed the diagnosis.

Pullorum was diagnosed in three batches of imported chickens. In one case mortality was about fifteen per cent. and in the other two about twenty per cent. This was followed up by a tightening of the importation requirements for day old chicks.

Listeriosis: Listeria monocytogenes was isolated from one of three birds which died suddenly in a backyard flock in Port Moresby.

Escherichia coli: Yolk sac infections were reported in imported chicks.

Fungal

Aspergillosis: Aspergillus sp. was isolated from the lungs of a chicken in the Morobe District.

Protozoan

Coccidiosis: One outbreak occurred in a flock of 200 birds in Port Moresby which were introduced as day old chicks to a building which had been free of fowls for eight months. Most owners use recommended coccidiostats to control the disease.

Helminth Infestations

The following helminth parasites were diagnosed.

Acuaria spiralis	*Oxyspirura mansoni*
Ascaridia galli	*Raillietina tetragona*
Heterakis gallinae	*Raillietina echinobothrida*

Ascaridia galli causes death occasionally, but is mainly responsible for poor production. Commercial poultry keepers spend large amounts on the control of this parasite.

Arthropod Infestations

Liponyssus bursa: This parasite was found infesting birds and causing loss of feathers. It was also reducing the resistance of the flock to a concurrent fowl pox infection.

Deficiency Diseases

Vitamin E Deficiency: The disease was diagnosed clinically and histologically. Treatment with vitamin E was effective.

DISEASES OF SMALL ANIMALS

The Veterinary Officers and Stock Inspectors of the Division are principally engaged in dealing with economic animals, but as no private veterinary practitioners are available, they attend to small animal cases also. As from 1st May 1963, the Administration has raised charges for services rendered to non-economic animals.

The following notes concern only the more important diseases; a full list of diseases identified is given under *Veterinary Research.*

Viral

Canine Distemper: Several cases were diagnosed in different parts of the Territory. In a number diagnosed clinically, no nervous involvement was noted. This, and the absence of distemper in Native-owned dogs, suggest that the local disease is not highly virulent. Many dogs were vaccinated with avianised vaccine.

Canine Hepatitis (Rubarth's Disease): A few cases were seen by all Veterinary Officers. Two deaths were recorded at Lae and the disease was confirmed histologically.

Canine Venereal Tumour: This disease is common and surgical treatment is often carried out. Two cases of nasal tumours were histologically indistinguishable from venereal tumours.

Feline Panleucopenia: Several cases were recorded and vaccinations were carried out.

Feline Pneumonitis: Five cases, all of which died, were recorded in Port Moresby, and two cases in Rabaul.

Bacterial

Otitis externa: Otitis is very common especially in long eared dogs. *Pseudomonas* sp. was cultured from some cases.

Pharyngitis: Pharyngitis, characterised by swelling of the submaxillary lymph nodes, was recorded in dogs.

Abscesses: Pasteurella septica, Streptococcus sp., *Staphylococcus aureus* and *Bacillus* sp. were cultured from abscesses in dogs and cats.

Fungal

Ringworm: Ringworm was diagnosed in dogs and cats.

Helminth Infestations

Dirofilaria immitis (Heart worm): Infestation is common throughout the Territory. It has been found in two unusual sites—thoracic cavity and abdominal cavity of dogs.

Anclyostomiasis and *Ascariasis:* Hookworm and Ascarid infestation were regularly seen. Treatment with tetrachlorethylene is recommended.

Arthropod Infestations

Fleas: Fleas are often seen in large numbers on both dogs and cats and may be, in part, the cause of severe dermatitis frequently seen in dogs.

Mange: Both sarcoptic and demodetic mange were diagnosed in dogs. *Notoedres cati* was recovered from cats.

Ticks: Rhipicephalus sanguineus was seen infesting dogs in several centres.

Myiasis: Fly strikes were recorded in dogs and cats but unfortunately the larvae were not identified.

Other Conditions

Atrophic myositis: This condition was seen in one dog and had previously been diagnosed in its mother. The masseter muscles were affected.

Osteodystrophia fibrosa: This is a common disease of cats and may be related to lowered calcium intake as a result of milk shortages in the Territory, the animals' diet being mainly tinned meat and rice. Treatment with Vitamin D and calcium preparations improved most cases.

Three cases of poisoning by toads were recorded in Lae, two of Dieldrin poisoning in Rabaul, and one of D.D.T. poisoning in Lae.

DISEASES OF NATIVE ANIMALS

Goura Pigeon (*Goura victoria*)

Visceral lymphomatosis was diagnosed histologically in one bird that died from the flock at the Lae Botanic Gardens.

Fork-tailed Kite (*Milvis migrans*)

Specimens of a filarial worm were found in the body cavity and air sacs of three birds. The worms were forwarded to Australia for identification.

Giant Echidna (*Zaglossus bartonii*)

Ticks of *Ixodes* sp. were collected from one specimen.

Tree-Climbing Kangaroo

Pseudomonas pseudomallei, the organism of Melioidosis, was cultured from abscesses of the spleen and liver and from the spinal cord of a Tree Climbing Kangaroo from a small zoo in Port Moresby. This is the first diagnosis of the disease confirmed bacteriologically in the Territory. A second Tree Climbing Kangaroo from the same zoo also had Melioidosis-like abscesses in the lungs but a culture resulted in a pure growth of *Pseudomonas pyocyaneus.* The position regarding melioidosis is discussed under *Veterinary Research.*

SLAUGHTERING AND MEAT INSPECTION

Veterinary Officers and Stock Inspectors of the Division provide slaughtering and meat inspection services. Slaughtering is carried out on small private slaughter floors, which must be constructed to requirements laid down by the Department. A standard plan drawn up by this Department and the Department of Public Works includes all the basic requirements.

The provision of central slaughtering facilities is essential to provide more efficient inspection service and to eliminate the waste of by-products which is characteristic of small basic slaughter floors. Site preparation for the Central Public Abattoirs in Lae was commenced in 1962-63 and the construction tenders will be let in 1963-64.

Central District

Slaughtering for sale was carried out on four slaughter floors while slaughtering for plantation use was also carried out at one of these floors. The total number of animals slaughtered were 549 cattle and 656 pigs in 1961-62 and 329 cattle and 633 pigs in 1962-63. There was a significant increase in pig slaughterings which can be explained by the continuation of the prohibition on the importation of pigmeats from Australia.

One condemnation for generalised tuberculosis was made. This was a reactor from the tuberculosis eradication campaign.

Northern District

Slaughtering continued on one property in this District which supplies the Port Moresby market. Carcases are air freighted to Port Moresby after having been chilled on the property. Mainly hindquarters are shipped to market, the forequarters being used for plantation rations. In 1961-62, 156 cattle were slaughtered and 214 in 1962-63. A series of liver samples from this property was forwarded to the Veterinary Laboratory as part of the investigation into the hepatic cirrhosis which was mentioned earlier.

Morobe District

Cattle for sale were slaughtered regularly at Lae, Wau, Bulolo, Zenag and Gusap. Cattle were also killed at other centres for local consumption. The total number of cattle slaughtered in 1961-62 was 409, together with an estimated 100 pigs, although accurate figures for pigs are not available. In 1962-63, 453 cattle were slaughtered for sale on 9 properties, and 102 for rations on 11 properties. At least 149 pigs were killed.

The establishment of the central abattoirs in Lae will provide an outlet for the turnoff from the increasing herds of the Morobe District as well as drawing from herds in the Highlands.

New Britain District

Killing of cattle for local sale in New Britain was at a very low level. Only two carcases, one being a buffalo, were inspected in 1961-62. In 1962-63, cattle killed at a plantation slaughterhouse in New Ireland were shipped in ice boxes to Rabaul and inspected on arrival. Ninety-six carcases were inspected.

Three small slaughterhouses operated to supply fresh pork to Rabaul. Numbers inspected were 1,639 in 1961-62 and 1,511 in 1962-63.

Madang District

Only 12 beef carcases, slaughtered for public sale, were inspected in 1962-63. Most slaughtering was for home use on plantations and missions, and numbers were 264 cattle and 291 pigs in 1961-62 and 452 cattle and 108 pigs in 1962-63.

Sepik District

No animals were inspected, but an estimated 100 were slaughtered for private use in 1962-63.

Highlands Districts

Records for these Districts do not cover animals slaughtered for private use, and because of distances involved it was not possible to inspect all carcases offered for public sale.

Statistics available showed 122 cattle slaughtered for sale in the Eastern Highlands in 1961-62; and in 1962-63, 54 cattle and 19 pigs for sale plus 89 cattle and 43 pigs slaughtered for private use. In the Western Highlands, in 1961-62, 54 cattle were slaughtered on the Western Highlands Livestock Station, Baiyer River, both for station rations and for sale to Government Stores at Mt. Hagen, and 36 were killed at the Hallstrom Trust Station, Nondugl. In 1962-63, 41 head of cattle and 17 pigs were slaughtered for home consumption, and 94 cattle and 68 pigs for sale.

TABLE 11. CLINICAL SERVICES PROVIDED

District	Year	Numbers of Consultations					
		Bovine	Equine	Porcine	Canine	Feline	Total
Central	1961–62 ..	345	43	39	316	104	847
	1962–63 ..	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**678**
Morobe	1961–62 ..	546	57	18	171	49	841
	1962–63 ..	**338**	**16**	**13**	**248**	**102**	**717**
New Britain	1961–62 ..	139	24	15	55	12	245
	1962–63 ..	**131**	**55**	**16**	**133**	**54**	**389**
Highlands	**1962–63 ..**	**825**	**72**	**83**	**53**	**13**	**1,046**
Sepik	**1962–63 ..**	**0**	**0**	**0**	**25**	**2**	**27**

CLINICAL SERVICES

Clinics were operated by Veterinary Officers in their respective Districts, while Stock Inspectors gave assistance where possible in other areas. The main diseases encountered are discussed above under *Disease Control and Investigation*. The numbers of consultations are shown in Table 11.

QUARANTINE SERVICES

The Division maintains supervision over the importation of all animals and animal products into the Territory. Regulations prohibit the entry of animals from all countries other than Australia and New Zealand. Following the outbreak of swine fever in Australia, importation of pigs and pigmeat from that source was prohibited in May 1961. This cut off all importations of pigs to the Territory, as New Zealand pigs are not allowed into Australia, and Papua-New Guinea had adopted the Australian regulations in this respect.

Animal products from countries other than Australia and New Zealand are permitted entry only with special permission from the Chief Stock Inspector and provided they are cooked to certain standards in hermetically sealed cans.

IMPORTATION OF ANIMALS

All animals were imported from Australia.

Cattle: A total of 533 head of cattle were imported in 1961-62. Twenty-two of these were imported for the Administration, and 459 were used to stock two large grazing properties in the Markham Valley. In 1962-63, 1,036 cattle were imported. These included 987 for Morobe District properties and 17 for an Eastern Highlands property. The Administration purchased 18 Africander Hereford cows, 1 Africander Bull and 13 Africander Shorthorn bulls from the C.S.I.R.O. National Cattle Breeding Station, " Belmont ", Rockhampton, Queensland.

Horses: Fourteen horses were imported in 1961-62 and 31 in 1962-63, mostly to the Morobe District. They included a number of Arabs for a small stud near Lae.

Pigs: Because of the prohibition mentioned under *Quarantine Services*, no pigs were imported.

Poultry: Apart from 36 goose eggs imported in 1962-63, all poultry were imported as day olds. Numbers were 116,705 chickens, 2,475 ducklings and 387 turkey poults in 1961-62, and 100,733 chickens, 1,055 ducklings and 187 turkey poults in 1962-63.

Goats: Three goats were imported to Rabaul in 1962-63.

Small Animals: Numbers imported were as follows:

	1961-62	1962-63
Dogs	38	60
Cats	7	11
Rabbits	0	6
Guinea pigs	6	0
Mice	220	399
Pigeons	11	2
Cage birds	740	156

Many of these importations were for laboratory work, including white mice used by workers from the Australian National University in studies into the viruses carried by mosquitoes in the Sepik District.

EXPORT OF ANIMALS

During 1961-62, one boar and three sows were exported from Lae to West New Guinea. No economic animals were exported in 1962-63.

VETERINARY RESEARCH

VETERINARY LABORATORY

DIAGNOSTIC SERVICE

The laboratory provides the diagnostic service for the field Veterinary Officers and for the pastoral industry. Some bacteriological diagnosis was also carried out on behalf of the Department of Public Health. A summary of the numbers of specimens handled is given in Table 12, and details of diagnoses are shown in Tables 13 and 14.

TABLE 12. SPECIMENS RECEIVED AT VETERINARY LABORATORY

Category		1961–62	1962–63
Microbiology	Blood Sera	5,098	14,076
	Other	265	1,194
Pathology		424	757
Parasitology		116	400

TABLE 13. DIAGNOSES AT VETERINARY LABORATORY, 1961–1963

BACTERIA, FUNGI, PROTOZOA AND NEOPLASMS

Type	Species Affected	Site
Bacteria and Fungi—		
Actinobacillus lignierisi	Bovine, Pig	Sub-cutaneous tissue muzzle and cheeks
Actinobacillus sp.	Wallaby	Abscesses, neck and lungs
Actinomyces sp.	Cat	Lung
Aspergillus sp.	Chicken	Lung
Arizona group	Dog	Faeces
Bacillus anthracis	Man	Skin
	Pig	All organs
	Goat	All organs
	Lab. rodents	All organs
Bacillus sp.	Bovine	Liver, lung, milk
	Pig	Lung
	Goat	Udder
	Dog	Wound
Brucella abortus	Bovine	Mammary lymph nodes
Candida sp.	Horse	Faeces
	Bird of Paradise	Lung
Citrobacter freundii	Man	Gut
Cloaca group	Bird	Spleen
Clostridium chauvoei	Bovine	Peripheral blood
Clostridium perfringens type A	Pig	Small intestine contents
Clostridium perfringens	Man	Gut
	Bovine	Heart blood
	Pig	Faeces
	Dog	Small intestine
Corynebacterium equi	Pig	Lymph node
Corynebacterium pyogenes	Bovine	Liver, uterus, lung, prepuce, jaw, precrural abscess, ear, udder, foetus
	Goat	Udder
	Pig	Lung, liver
Corynebacterium sp.	Bovine	Skin, urine
	Dog	Abscess
	Cat	Lungs
Dermatophilus dermatonomus	Bovine	Skin plaques
Erysipelothrix rhusiopathiae	Pig	Heart
Escherichia coli	Bovine	Fatal endocarditis, mastitis
	Pig	Lung, neonatal death
	Goat	Lymph node
	Poultry	Spleen, yolk sac infection
	Lab. rodent	Peritoneal cavity
Klebsiella pneumoniae	Pig	Mastitis
	Cat	Lung
Lactobacillus casei	Bovine	Milk
Listeria monocytogenes	Poultry	Pericardial fluid
Mycobacterium tuberculosis	Bovine	Demonstrated in mesenteric lymph nodes
Nocardia asteroides	Wallaby	Abscess, spleen
Nocardia spp.	Bovine	Traumatic reticulitis
	Dog	*Spirocerca lupi* nodules and skin lesions
	Cat	Skin lesions
Pasteurella septica	Pig	Lung
	Dog	Wound
	Cat	Wound
Proteus vulgaris	Bovine	Autopsy material
	Lab. rodents	Wound
Pseudomonas pseudomallei	Goat	All organs
	Marsupial	All organs
	Lab. rodents	All organs
Pseudomonas aeruginosa	Horse	Liver, spleen
	Bovine	Milk
	Pig	Lung
Rhinosporidium seeberi	Bovine	Nasal septum
Salmonella san diego	Cat	Intestinal tract
Salmonella paratyphi C.	Horse	Gut
Salmonella pullorum	Poultry	Ovaries
Salmonella weltevreden	Guinea pig	Spleen, peritoneal cavity
Salmonella Group D	Pig	Faeces
Salmonella Group E	Pig	Placenta
	Lab. rodents	All organs
Staphylococcus aureus	Dog	Abscesses
	Cat	Abscesses
Staphylococcus spp.	Bovine	Liver, lymph glands, mastitis
	Pig	Umbilicus, lung
	Goat	Udder
Streptococcus Group D	Bovine	Peripheral blood
Streptococcus spp.	Bovine	Liver, lung, milk
	Dog	Abscesses
	Cat	Abscesses
Vibrio fetus	Bovine	Vaginal mucus, aborted foetus
Protozoa—		
Babesia sp.	Bovine	Blood
Eimeria sp.	Poultry	Faeces

Type	*Species Affected*	*Site*
Neoplasms—		
Adenocarcinoma	Bovine ..	Nasal cavity, liver
	Poultry ..	Liver, gastrointestinal tract, genitalia
	Cat ..	Tongue
	Budgerigar	Kidney
Adenoma ..	Pigeon ..	Neck
Carcinoma ..	Cat ..	Skin
Fibroma ..	Bovine ..	Digit
	Cat	Ear
Fibrosarcoma ..	Lab. rodent	Connective tissue
Haemangioma ..	Bovine ..	Bladder
Haemangiopericytoma ..	Dog ..	Stifle
Hepatoma ..	Bovine ..	Liver
	Dog ..	Liver
Lipoma ..	Dog ..	Leg
Lymphomatosis	Poultry ..	Intestine
	Budgerigar	Liver
Lymphosarcoma	Horse ..	Thoracic organs, liver, small intestine
Malignant lymphoma	Bovine ..	Lymph gland
	Pig ..	Spleen, gastro-intestinal tract, lymph gland
	Dog ..	Spleen
Melanoma ..	Bovine ..	Skin
Neurofibroma ..	Bovine ..	Heart
Seminoma ..	Dog ..	Testis
Sertoli cell tumour	Bovine ..	Testis
	Dog ..	Testis
Squamous cell carcinoma	Bovine ..	Eye
	Dog ..	Gum, scrotum
	Cat	Jaw, ear
Transmissible venereal tumour	Dog ..	Genitalia, nasal cavity, conjunctiva, lymph gland, salivary gland

TABLE 14. DIAGNOSES AT VETERINARY LABORATORY, 1961–63

ARTHROPODS AND HELMINTHS

Parasite	*Host*
Arthropods—	
Amblyomma sp.	Cattle
Boophilus microplus	Cattle
Chrysomya bezziana ..	Man, cattle, horse, pig, dog
Demodex sp.	Dog
Gastrophilus sp.	Horse
Haemophysalis novae guineae ..	Cattle, horse, pig
Haematopinus suis	Pig
Heterodoxus longitarsus ..	Wallaby
Ixodes sp.	Cattle, horse, pig, marsupial
Rhipicephalus sanguineus ..	Dog
Sarcoptes scabei	Pig
Cestodes—	
Anaplocephala perfoliata ..	Horse
Cysticercus tenuicollis ..	Sheep
Diphyllobothrium sp. ..	Cat
Dipylidium canum	Dog
Monezia sp.	Cattle
Raillietana sp.	Poultry
Trematodes—	
Fasciola hepatica	Cattle, sheep
Paramphistomum cervi ..	Cattle
Nematodes—	
Acuria spiralis	Poultry
Ancylostoma caninum ..	Dog
Ascaridia galli	Poultry
Ascaris equorum	Horse
Ascaris suum	Pig
Ascarops strongylina ..	Pig
Bunostomum phlebotomum ..	Cattle
Cooperia sp.	Cattle
Dirofilaria immitis	Dog
Filarioids	Marsupial
Habronema muscae ..	Horse
Haemonchus contortus ..	Cattle, sheep
Macracanthorychus hirudinaceus	Pig
Nematodirus sp.	Cattle
Neoascaris vitulorum ..	Cattle
Oesophagostomum spp. ..	Cattle
Ostertagia spp.	Cattle
Oxyuris equi	Horse
Parascaris equorum ..	Horse
Spirocerca lupi	Dog
Strongyloides papillosus ..	Cattle
Strongyloides sp. ..	Sheep
Strongylus sp.	Horse
Trichostrongylus axei ..	Horse
Trichostrongylus equi ..	Horse
Trichostrongylus spp. ..	Cattle, sheep
Trichuris ovis	Sheep

RESEARCH

Anthrax

Work on anthrax of pigs proceeded along three lines, as described below.

Bacteriological Studies: Tests of the bacteriological characters of the New Guinea strain of *Bacillus anthracis* were made as shown in Table 15. These tests have been used previously in a comparative survey and classification of the genus *Bacillus.*

TABLE 15. CHARACTERISTICS OF NEW GUINEA STRAIN OF BACILLUS ANTHRACIS

Test	Bacillus anthracis *and* B. cereus	*New Guinea Strain*
Growth on Nutrient Agar ..	+++	+++
Voges-Proskauer Test for Acetone Production	+	+
Starch	+	+
Digestion of—		
(1) Casein	+	+
(2) Gelatin	+	+
(3) Egg Yolk	+	+
Nitrate Reduction	+	+
Anaerobic Growth	+	+
Gibson Abdel Malek Test ..	−	−

At 20 degrees Centigrade the New Guinea Strain forms a typical inverted fir tree growth in gelatin, and it appears to have characteristics identical with those described for the organism in other countries.

Pathogenicity Studies: An investigation was made of the pathogenicity of the organism and its antigenic relationship to classical strains of *B. anthracis*.

The New Guinea organism was found to be pathogenic in low doses for guinea pigs, mice and goats. At death the organism was recoverable from all organs and body discharges. Death in the experimental animal was invariably accompanied by bacteraemia.

In an attempt to investigate the serology of the organism, advantage was taken of the availability of the serum from a human case of the disease. Serum samples were taken at the acute stage of the disease and four weeks after recovery. Precipitating antigen was prepared by boiling a culture of the organism for 20 minutes. After centrifugation the clear supernatent was used as antigen. A twofold difference in titre was demonstrated between acute and convalescent serum. The significance of the difference is doubtful as the experiment was not controlled with known normal serum. This precipitation test does however provide a basis for further serological work.

A recent case of the disease in man suggests that an investigation of the apparent immunity of large numbers of the native population in areas where the pig disease is endemic is warranted. It also suggests that the disease may be more frequent in man than was formerly thought.

Vaccine Evaluation: In a preliminary test with goats, evidence was obtained that McGarvie Smith spore vaccine protects against the disease. Two vaccinated goats survived challenge with 20,000 virulent organisms, while two unvaccinated animals challenged with the same dose died of the disease at four and five days respectively.

Further evalution of anthrax vaccines was carried out at the Animal Industry Centre, Goroka. Results are summarized in Table 16. They indicate that vaccination gave a solid immunity to challenge with intravenous or intramuscular injections of spores.

TABLE 16. EVALUATION OF ANTHRAX VACCINE

Period after Vaccination	*Number of Animals*	*Challenge Dose*	*Result*
3 months ..	7	1 x 10^6 spores i/v	Survived
7 months ..	2	6 x 10^6 spores i/v	Survived
7 months ..	2	6 x 10^6 spores i/m	Survived
12 months..	1	6 x 10^6 spores i/v	Survived

i/v = intravenous. i/m = intramuscular: deep injection into tissue of intermandibular space.

Experiments aim to determine the longevity of the protection conferred on the adult pig by a single vaccination, and also to indicate whether the protection is shorter-lived when pigs are vaccinated at eight weeks of age.

Vaccination of 1,049 pigs was carried out in the Lumi Sub-District of the Sepik District in an attempt to contain an outbreak of anthrax within a band of treated animals. A new outbreak was reported some months after vaccination in non-vaccinated pigs on the fringe of the treated area.

Haemorrhagic Septicaemia Syndrome

No herd outbreaks were recorded, but sporadic deaths occurred on five properties in the Central District. One case was autopsied within half an hour of death which was preceded by a rectal temperature of 109° F. *Pasteurella septica* was not cultured from this case or from any of the others autopsied. Table 17 gives a list of organisms cultured and their site of recovery.

TABLE 17. ORGANISMS FROM SUSPECT HAEMORRHAGIC SEPTICAEMIA DISEASE

Herd	*Site*			
	Liver	*Blood*	*Respiratory System*	*Bone Marrow*
1	*Bacillus* sp.	N.O.C. ..	N.O.C. ..	N.C.
2	*E. coli* A–D Group	N.O.C. ..	Streptococci *Bacillus* sp. Staphylococci	N.O.C.
3	N.C. ..	N.O.C. ..	Staphylococci Haemolytic *Bacillus* sp. Non-Haemolytic *Bacillus* sp.	N.C.
4	N.C. ..	*Clostridium perfringens*	*C. pyogenes* Streptococci Staphylococci	N.O.C.

N.C. Not cultured. N.O.C. No organism cultured.

Bone marrow was inoculated directly into mice in two cases but *P. septica* was not recovered. Despite the similarity between this disease entity and haemorrhagic septicaemia and the fact that *P. septica* has on occasion been isolated from cases, this disease in the Central District does not appear to be pasteurellosis of cattle. The main reasons for this conclusion are—

(i) Inability to transmit the disease directly to mice.

(ii) *P. septica* is relatively easily isolated from diseased animals even in competition with other organisms and it should therefore be readily and consistently cultured from all cases of the disease.

Further intensive investigation of the etiology of the disease is necessary.

Melioidosis

Melioidosis was diagnosed in a tree climbing kangaroo and some limited investigations were carried out on the characteristics of the organism. These were found to agree with those desribed in other parts of the world. Serial samples of serum from an experimentally infected goat were forwarded to the Animal Research Institute, Yeerongpilly, Queensland, for serological confirmation of the identity of the organism. The results are given in Table 18. A titre of 1/20 is regarded as positive.

TABLE 18. SEROLOGICAL TEST FOR MELIOIDOSIS EXPERIMENTALLY INFECTED GOAT

Date Sampled	*Titre*
Inoculation	Negative
3 days	Negative
6 days	1/20
9 days	1/20
18 days	1/20
21 days	1/40
24 days	1/40
41 days	1/40

Attempts will be made to carry out the test at the laboratory and survey the incidence and distribution of the disease.

Clostridium perfringens *Infection in Man*

An outbreak of suspected enteritis necroticans in man in the highlands, following ingestion of pigmeat, resulted in the laboratory undertaking isolation of the causal organism from clinical cases and also from pigs and pigmeats.

Clostridium perfringens was consistently isolated from resected gut sections taken from human surgical cases and from post mortem material. Typing of isolates by the Wellcome Research Laboratories showed the majority to be *Cl. perfringens* type C. Type C has been isolated from pigs previously and as most cases of human enteritis necroticans are associated with pig feasts, an epidemiological relationship between human cases and pig feasting seems likely. As yet no *Cl. perfringens* type C has been isolated in the current survey of pigs. In 110 pigs at Goroka, 12 were carriers of *Cl. perfringens* type A, and 4 of 11 samples at Korfena were also carriers of type A. More comprehensive sampling is planned for the coming year.

Salmonella Survey

A survey showed only low incidence of *Salmonella* in Territory pigs and cattle. One positive reactor from each group was obtained in 143 bovine faecal samples, 309 porcine faecal samples and 109 porcine mediastinal lymph nodes.

Vibriosis

Mucus samples were tested from cattle at the Papuan Highlands Livestock Station, Bisianumu; the Papuan Lowlands Livestock Station, Moitaka; and the New Guinea Lowlands Livestock Station, Erap. Results are shown in Table 19.

TABLE 19. RESULTS OF VIBRIOSIS TESTING ON THREE CATTLE HERDS

Source	*Number of Samples*	*Number Positive*	*Number Suspicious*
Moitaka ..	44	9	6
Bisianumu ..	34	1	3
Erap	9	0	1

The results indicate definite presence of the disease at Moitaka and Bisianumu. An organism considered to be *Vibrio fetus* was cultured from vaginal mucus of a Moitaka cow.

Mineral Deficiences

The Agricultural Chemistry section carried out serum calcium and phosphorus determinations on cattle

sera from three Administration Livestock Stations, in connection with studies on low fertility in British breeds of cattle. The samples were taken from pregnant, non-pregnant, lactating and non-lactating cows. Few values were not within the normal range, and there appeared to be no significant difference between wet and dry cows or between cows in oestrus and not in oestrus.

Screw Worm Fly

The preliminary investigation by Messrs. Murray and Norris of C.S.I.R.O. is reported above under *Disease Control and Investigation*. Little further work was possible, other than identification of larvae collected from strikes, because the Division had no Parasitologist.

FIELD RESEARCH

Research programmes at a local level were carried out by field Veterinary Officers, particularly at Lae. All problems are of a long term nature, and results are presented generally with no attempt to draw conclusions.

Internal Parasites of Cattle

Internal parasitism is becoming of increasing importance especially as stocking rates increase in the higher rainfall zones of the Territory. The occasional deaths which occur indicate to the stock owners the obvious losses from internal parasites but the insidious losses from lowered production are more difficult to demonstrate. The aim of the research is to determine whether regular prophylactic treatment of stock to prevent these insidious losses is economically sound.

Initial investigations were based on faecal egg counts in samples collected in the Morobe District. These were classified in three groups according to environment: Morobe coastal, from high rainfall lowland environment where pastures have been planted on cleared rainforest; Morobe inland, from the lower rainfall, lowland, natural grass areas of the Markham Valley; and Morobe highland, from higher altitude pastures. Results are presented in Table 20.

TABLE 20. EGG COUNTS IN CATTLE FAECES. MOROBE DISTRICT

Area	*Number of Samples*	*Average Numbers of Eggs (x100) per Gram*		
		Strongylus	*Strongyloides*	*Total*
Coastal ..	143	16 (2–44)	17 (2–49)	33 (2–93)
Inland ..	40	5 (4–5)	3 (2–7)	8 (5–12)
Highlands	53	6 (2–30)	2 (0–5)	8 (4–30)
Total ..	236	12	11	23

Note: Figures in parenthesis indicate range of counts.

Extremely high figures at one dairy property indicated the need for drenching and rotational grazing. Monthly drenching without rotational grazing reduced worm counts from a total of 27,800 e.p.g. (eggs per gram) to 2,400 e.p.g., but they rose rapidly to 21,000 e.p.g. by the next month.

At the Animal Industry Centre, Three Mile, Lae, initial counts of 1,800 e.p.g. were reduced to less than 200 e.p.g. by one drenching and remained around that level for at least 5 months. The lower stocking rates and rotational grazing practised at the Centre were probably responsible for the delay in reinfestation.

A trial will commence shortly at the New Guinea Lowlands Livestock Station, Erap, running together two groups of weaners, one group being drenched monthly with " Thibenzol " and the other being untreated as a control. Regular weighings will be made. The trial should indicate whether drenchings are economical in the Morobe inland area.

Bovine Fertility

Investigation of the level of fertility on five properties in the Morobe District was undertaken in 1961-62. Three of the properties have small herds which are run as a single mob with continuous mating. One of the other properties began a system of restricting mating with pregnancy diagnosis to determine the success of the mating. This property was newly stocked with imported cattle, all of them being heifers in their first pregnancy or maiden heifers when imported. The figures in Table 21 give the results of pregnancy diagnosis on this herd.

TABLE 21. PREGNANCY DIAGNOSIS IN A MARKHAM VALLEY HERD

Date	Not Previously Examined			Examined Previously and Non-pregnant			Progressive Total		
	No.	Pregnant	Per cent.	No.	Pregnant	Per cent.	No.	Pregnant	Per cent.
2.8.61	120	44	37	..	..	..	120	44	37
27.12.61	93	63	68	72	44	61	213	151	71
21.2.62	4	2	50	49	17	53	217	170	78
11.5.62	..	..	..	28	9	32	217	179	82

The herd is now mated continuously with regular pregnancy diagnosis to segregate the pregnant cows from the mating groups. Cows are returned to the mating group after their calves are born.

Table 22 shows the breeding performance of the five herds tested. The survey will be continued in the coming year and will be extended to other herds.

Observations on one of these properties indicated a correlation between coat type and breeding performance. Percentage of cows milking and/or pregnant according to coat type were: woolly, 67 per cent; medium, 83 per cent; fine, 93 per cent.

Observations were also made at Erap on a group of cows which had not calved for at least four years, to determine whether they were coming into oestrus and also the frequency of oestrus. Sixty Shorthorn cows were run with three Shortorn bulls fitted with marking halters. Some 40 per cent. exhibited oestrus and returned every 20-22 days. The remainder did not exhibit oestrus, although only three were pregnant. The barren cows were subsequently sold.

Copper-Cobalt Supplementation

Trials were undertaken at the Western Highlands Livestock Station, Baiyer River, and the New Guinea Lowlands Livestock Station at Erap. Groups of eight steers were treated at Erap and groups of twelve at Baiyer River. One group was treated with copper glycinate injection, a second with cobalt bullets, a third with both, whilst a fourth group acted as a control. Regular weighings were made. Results were inconclusive at Baiyer River whilst at Erap it seems that no benefit was gained from copper or cobalt supplementation.

Screw Worm Fly

Collections of screw worm larvae were made by field officers as part of the preliminary research into the distribution of the parasite throughout the Territory. The incidence of strike within herds was also observed, to record breed susceptibility and the commonest sites of strikes. The value of prophylactic spraying treatments is also being tested.

TABLE 22. BREEDING PERFORMANCES ON FIVE MOROBE DISTRICT PROPERTIES

Herd No.	Location	Year	Breeders	Bull Percentage	Calves born	Calves Weaned
					per cent.	per cent.
1	Markham Valley	1961 ..	10	10	120	100
		1962 ..	18	6	72*	..
2	Coastal	1961 ..	28	3.5	100	100
3	Markham Valley	1960 ..	30	6.5	76	..
		1961 ..	28	11	64	53
4	Ramu Valley	1962 ..	..	..	100†	..
5	Markham Valley	1961–62 ..	..	..	82‡	..

* Calves born and pregnancy diagnosis. † Sample of 60 cows from 280 breeders on basis of calves born and pregnancy diagnosis.
‡ Herd in Table 15 above.
Herds 1, 3 and 5 are British breeds of cows, herds 2 and 4 are Zebu cross cows.

Plate 3. Recording the liveweight of a Berkshire pig prior to its sale to a village farmer. (*Photo: D.I.E.S.*)

ANIMAL HUSBANDRY

EXTENSION OF ANIMAL INDUSTRIES TO NATIVE PEOPLES

Pigs

The programme of upgrading local pigs was continued through distribution of Berkshire pigs from the Division's herds in the Eastern Highlands, Morobe and New Britain Districts, and through lending boars to villagers for periods of up to three weeks to serve village sows. Young native-type pigs were recently purchased for the Goroka piggery for observation of their performance under good husbandry conditions and for inclusion in a cross-breeding programme. The aim is to breed a type of pig that will combine the good features of the European breeds with the hardiness and adaptation to grazing of the native pig. Selection for good performance under local conditions is also practised in the Berkshire herds.

Some advance has been made with efforts to encourage improved pig husbandry practices in the economically more advanced areas. There has been appreciable improvement in methods used by individual owners around Rabaul, where a large market for pigs is available.

Cattle

Villagers are being encouraged to replace the pig as the village grazing animal with cattle and so to utilize more effectively the large grassland areas of the Territory. Cattle projects were greatly extended during the two years, as shown in Table 23.

TABLE 23. DEVELOPMENT OF VILLAGE CATTLE PROJECTS

District	*Number of Cattle*		
	1960–61	*1961–62*	*1962–63*
Morobe	320	483	518
Eastern Highlands ..	59	98	146
Western Highlands ..	0	0	27
Total ..	379	581	691

There is intense interest by village people in purchase of cattle and rapid expansion is expected, particularly in the Highlands Districts. In the lowlands areas, especially the Markham Valley where there is considerable potential for expansion, the rate of progress is to some extent limited by the availability of heat tolerant cattle from the Department's crossbreeding programme. Initially, steers are sold to new projects to reduce the drain on breeding herds and also because steers are simpler to manage while the owners are still novices in cattle handling.

Two model village projects are nearing completion in the Morobe District, featuring a small night paddock planted with improved pasture and small yards with a roofed crush. During the day the cattle are to be herded out on an extensive basis.

An intensified programme to increase the number of cattle projects will be undertaken next year. Schools are to be set up at the Livestock Stations at Erap and Baiyer River to train large numbers of villagers to manage the projects. The course will cover elementary anatomy, physiology, breeding, animal husbandry and pasture improvement. Much use will be made of visual aids to assist the villagers in assimilating the lectures. They will spend some weeks handling stock, planting grasses and legumes, dressing wounds, castrating and branding.

LIVESTOCK STATIONS

Eight livestock stations are operated by the Division throughout Papua and New Guinea. Two, the Animal Quarantine Station and Veterinary Laboratory, Kila Kila, Port Moresby, and the Animal Industry Centre, Three Mile, Lae, function as quarantine centres and bases from which Veterinary Officers and Stock Inspectors operate. The Papuan Lowlands Livestock Station, Moitaka, the Papuan Highlands Livestock Station, Bisianumu, the New Guinea Lowlands Livestock Station, Erap, and Western Highlands Livestock Station, Baiyer River, maintain herds of cattle for breeding, experiment, and distribution. The Animal Industry Centre, Goroka, maintains a dairy herd and a large stud piggery project. The Animal Industry Centre, Kurakakaul, Rabaul, functions as a quarantine area and Veterinary Centre as well as maintaining a dairy herd and piggery project.

At June 30 1963, these stations carried a total of 3,610 cattle, 294 horses, 296 pigs, 54 donkeys, 9 goats and 7 sheep. Detailed statistics of cattle, horses and pigs for all Animal Industry Stations are shown in Table 24.

TABLE 24. LIVESTOCK STATISTICS FOR ANIMAL INDUSTRY STATIONS, 1961–63

Livestock	Station	Total 1st July 1961	Natural Increase and Transfers In	Deaths	Slaughtered for Consumption	Sales and Transfers Out	Total 30th June 1963
Cattle ..	Moitaka	847	644	68	3	262	1,158
	Bisianumu	264	143	15	0	108	284
	Erap	493	548	54	19	290	678
	Goroka	31	90	6	5	59	51
	Baiyer River	1,154	830	84	76	615	1,209
	Kurakakaul	150	116	20	33	27	186
	Three-Mile	25	28	12	0	6	35
	Kila Kila	8	23	5	0	17	9
Horses ..	Moitaka	67	43	10	0	15	85
	Bisianumu	5	3	1	0	1	6
	Erap	55	34	5	0	12	72
	Goroka	1	1	0	0	1	1
	Baiyer River	116	49	8	1	51	105
	Kurakakaul	14	10	4	0	0	21
	Three-Mile	2	4	0	0	2	4
	Kila Kila	2	1	0	0	2	1
Pigs ..	Erap	28	233	90	5	123	43
	Goroka	72	464	48	26	314	148
	Baiyer River	7	4	3	0	1	7
	Kurakakaul	19	135	32	12	32	78
	Three-Mile	1	42	0	0	43	0
	Kila Kila	0	18	3	0	0	15

Table 25 gives a summary of sales of livestock from the Animal Industry Stations.

TABLE 25. SALES OF LIVESTOCK FROM ANIMAL INDUSTRY STATIONS 1961–1963

Category	1961–62		1962–63	
	Number Sold	Revenue	Number Sold	Revenue
		£ s. d.		£ s. d.
Cattle ..	377	9,894 10 0	381	8,665 10 0
Pigs ..	182	1,741 0 0	170	1,592 0 0
Horses ..	0	..	27	701 0 0
Donkeys ..	5	100 0 0	4	30 0 0

A review follows of the four main projects being undertaken, while greater detail is given in reports of individual Livestock Stations.

Zebu Cross-Breeding Project

The two sections, as described in the 1960-61 Annual Report, are continuing with some modifications.

(i) Brahman cross-breeding on the Papuan Lowlands Livestock Station, Moitaka, using Angus and Poll Shorthorn breeders. The Papuan Highlands Livestock Station, Bisianumu, is also producing some Brahman crossbred cattle for this programme.

(ii) Crossbreeding of Africander and Poll Shorthorn on the New Guinea Lowlands Livestock Station, Erap. Following unsatisfactory breeding performance of Shorthorn cows, 50 Brahman-Shorthorn cross heifers were introduced in July 1962. Africander-Brahman-Shorthorns will be produced, with the female progeny to be bred back to Africander-Shorthorn bulls. Eighteen Africander-Hereford cows and 13 Africander-Shorthorn bulls were introduced in February 1963, from the C.S.I.R.O. National Cattle Breeding Station, " Belmont ", Queensland. The Western Highlands Livestock Station, Baiyer River, has also been brought into the programme to assist in restocking the Erap Station as quickly as possible with part Africander stock. The Baiyer River Station is producing quarter and half Africander female stock, and an Africander bull from " Belmont " was introduced in 1963.

Dairy Cattle Improvement

The dairy breeding project continues as described in the 1960-61 Annual Report. Jerseys, being more heat tolerant, are run on the lowlands Stations, Moitaka and Kurakakaul, and A.I.S. are used at Goroka in the Highlands. Emphasis is on milk, rather than butterfat, production.

Plate 4. Brahman-Angus heifers at the Papuan Lowlands Livestock Station, Moitaka. (*Photo: D.I.E.S.*)

Pig Breeding Project

Stud Berkshire pigs are maintained at the Animal Industry Centres, Kurakakaul and Goroka, and at Erap and Baiyer River Livestock Stations. Selection of breeders is based on litter size and growth rate, and stock other than replacement breeders are distributed, mainly to Native peoples.

Beef Cattle Breeding Project

Breeding of European breeds of beef cattle is carried out on the Papuan Highlands Livestock Station, Bisianumu (Angus and Red Polls), and Western Highlands Livestock Station, Baiyer River (Poll-Shorthorns). Both these stations have now been partly given over to breeding crossbred replacements to increase the rate of restocking of the lowland stations. Surplus breeders are made available for sale to Native peoples while steers and culled cows are sold at public auction.

Selection within the herds is directed towards coat type, weight gain and conformation, but the urgent need for the largest possible increase in size of Administration herds together with the maximum turnoff of heifers to cattle projects decreases the effective culling level so that only very defective females are culled. Continued efforts are being made to improve breeding efficiency and reduce mortalities.

PAPUAN LOWLANDS LIVESTOCK STATION, MOITAKA

A description of the Station was given in the 1960-61 Annual Report. Rainfall data are shown in Appendix IV of this report. Capital improvements during the two years have included a four-stand brick dairy with an attendant calf-rearing pen, a slaughter house and butcher shop with a 300 cu. ft. refrigerator, a weighbridge for weight-gain observations at the Waigani stockyards and new labour accommodation.

Cattle (Dairy)

Recording of milk production continued, and results for some of the cows are shown in Table 26. Cows were machine milked twice daily and production recorded once every fourteen days at each milking. Increased average production and length of lactation in 1961-62 were obtained when an area of improved irrigated pasture was made available to the lactating cows. The decline in 1962-63 may be a result of the

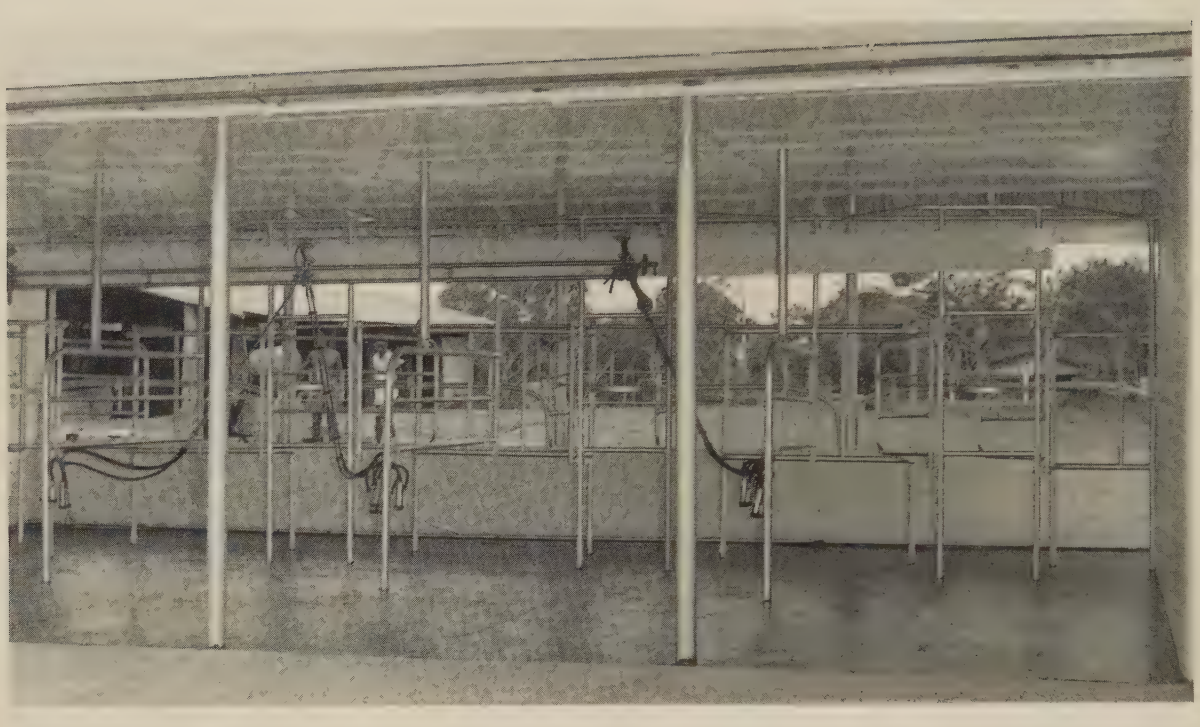

Plate 5. The new dairy at the Papuan Lowlands Livestock Station, Moitaka. (*Photo: D.I.E.S.*)

advancing age of these cows, most of which are ten years old. Sufficient heifers are now available to replace aged cows.

TABLE 26. LACTATION OF JERSEY COWS AT MOITAKA

Cow No.	*1960–61*		*1961–62*		*1962–63*	
	Lactation Length	*Yield*	*Lactation Length*	*Yield*	*Lactation Length*	*Yield*
	days	*lb.*	*days*	*lb.*	*days*	*lb.*
3001 ..	..	..	305	4,865	305	3,174
3014 ..	..	..	305	6,292	305	6,120
3017 ..	269	3,793	236	2,965	305	4,805
3024 ..	300	5,685	305	6,248	296	4,664
3033 ..	297	4,633	211	3,640	145	752
3034 ..	226	2,497	305	3,649	261	3,124
3037 ..	306	3,372	..	..	282	3,895
3038 ..	..	..	305	5,139	305	4,211
3040 ..	358	6,284	..	..	305	5,600
3045 ..	241	2,534	272	3,738	275	2,775
3046 ..	210	3,298	269	3,860	305	4,130
3048 ..	306	2,519	305	4,088	305	3,021
3055 ..	275	4,105	305	5,806	305	3,685
3059 ..	226	2,770	305	4,115	305	3,308
Av. ..	274	3,772	285	4,538	287	3,805

Bull calves from the best producers are retained for use over the whole herd. The culling level for cows has been set at 200 days lactation with a production of 2,000 lb. of milk.

Cattle (Beef)

The Brahman crossbreeding programme progressed satisfactorily, although handicapped by the limited number of pure Brahman bulls. All calves dropped in 1962-63 were at least one quarter Brahman. Evidence from weight-gain trials and general observation indicates that cows probably require three-quarters Brahman blood to be able to rear good calves, while maintaining condition themselves, on native pastures in the dry areas of the Central District. The weight gain trial using Angus heifers and Brahman Angus F_1 heifers reported in the 1960-61 Annual report was completed during 1962. The complete results are given in both tabular (Table 27) and graphical (Figure 5) form. The trial ceased in February 1962, because the heifers began to calve to a mating commenced in May 1961. All of the F_1 Brahman Angus heifers and all but one of the Angus heifers calved.

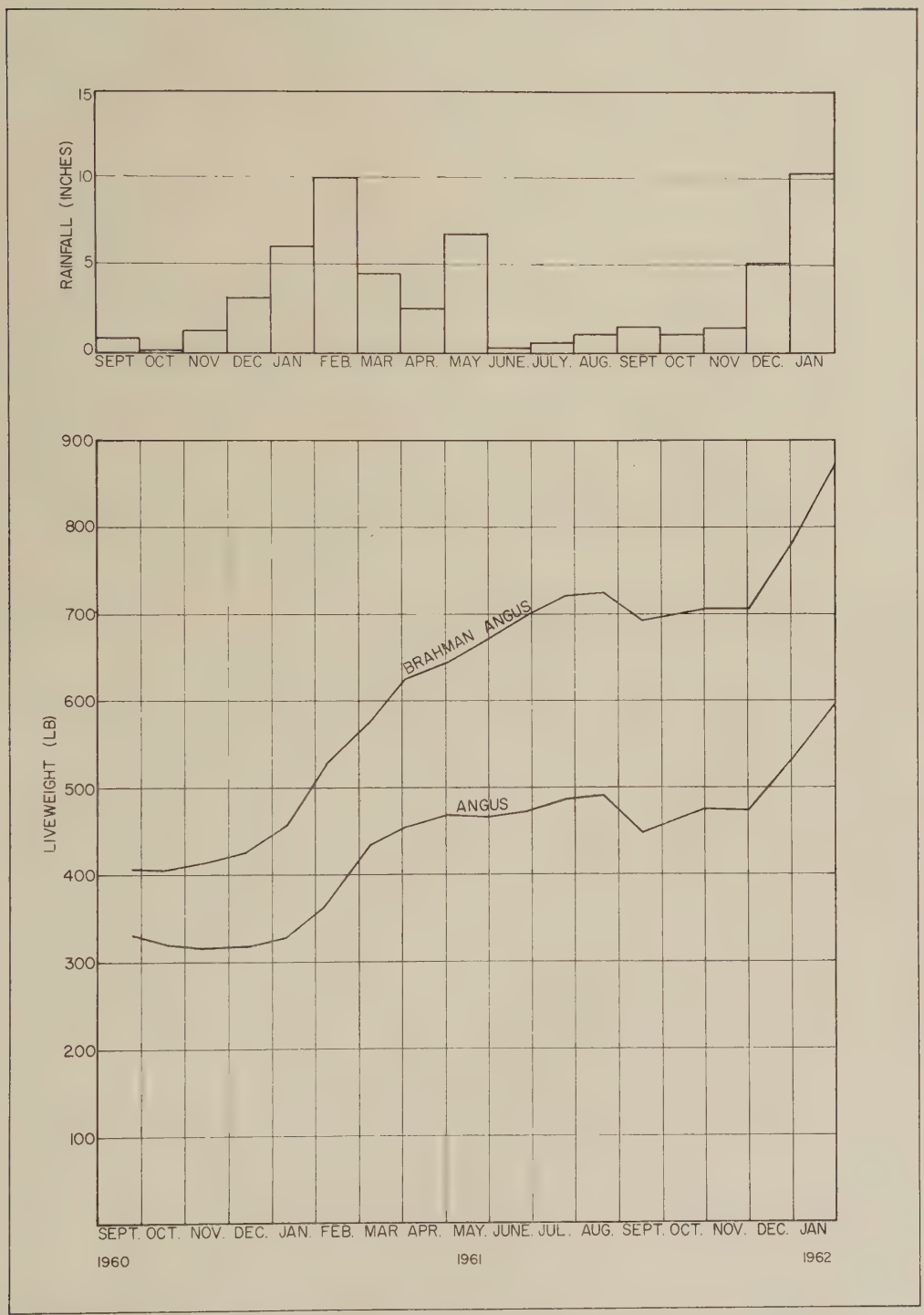

Figure 5: Comparative weights of Angus and Brahman-Angus calves at Papuan Lowlands Livestock Station, Moitaka, in relation to rainfall.

TABLE 27. COMPARATIVE WEIGHTS OF ANGUS AND BRAHMAN-ANGUS CALVES

Dates	*Angus*	*Brahman-Angus*
	lb.	*lb.*
26.9.60	331.2	407.2
17.10.60	322.4	405.6
15.11.60	317.6	414.4
13.12.60	318.4	427.2
10.1.61	329.6	459.2
7.2.61	364.4	528.4
7.3.61	433.6	576.4
4.4.61	452.8	625.6
2.5.61	468.8	644.6
30.5.61	466.4	670.4
27.6.61	472.0	700.0
25.7.61	487.6	720.8
22.8.61	489.6	724.4
19.9.61	448.8	692.0
31.10.61	475.6	706.4
30.11.61	472.8	705.0
2.1.62	536.4	780.8
1.2.62	587.2	863.2

The mean gain of the F_1 Brahman Angus heifers over the trial was 456 lb. or 0.925 lb. per day while the Angus heifers gained 256 lb. or 0.519 lb. per day. This trial clearly showed the marked superiority of the F_1 Brahman Angus over pure Angus under the conditions of the trial. For the duration of the trial they were set grazed on the same natural pasture, consisting mainly of Kangaroo grass (*Themeda* sp.) and kunai (*Imperata cylindrica*). They were given no supplementary feeding. Weighings were carried out at approximately monthly intervals after a night of starvation in the stockyards. On completion of the weighings the animals were returned to the breeding herd.

A second trial was commenced on 1st February, 1962, which included ¾ Brahman Angus, ½ Brahman Angus (F_1) and ¼ Brahman Angus heifers, treated in the same manner as in the trial described above. Results up to June, 1963, are presented graphically in Figure 6.

Calving improved from 30.6 per cent. in 1960-61 to 45 per cent. in 1961-62 and 62 per cent. in 1962-63. The improvement may be attributed to the increasing proportion of crossbred stock in the breeding group, an increased percentage of young bulls, and all year round matings in 1962-63 when bulls were allowed to run continuously with the cows. In 1961-62, calving for Angus cows was 41.4 per cent. (148/360) against 67 per cent (40/60) for crossbred cows.

Annual sales of stock were held in June, 1962, and June, 1963, with rather disappointing results. Average prices for Brahman crossbred bulls were as follows:

—	*1961*	*1962*	*1963*
	£	£	£
¾ Brahman bulls	272	64	25
½ Brahman bulls	107	37	20

It appears that at present the local demand for crossbred bulls is minimal, but it is expected that the demand will rise again as the industry develops.

Horses

Nineteen foals were born, sired by "Woodmaster" out of station and captured brumby mares. There is a need for a new stallion to use over "Woodmaster's" three year old fillies.

Goats

These were slaughtered out in 1961-62. Their elimination improved the condition of both natural and improved pastures over the area where they had grazed.

Pasture Improvement

Pasture improvement was continued, using mainly elephant grass and *Centrosema*. Para grass plantings on swamp margins were extended to 150 acres. The area of irrigated pastures for the dairy herd was increased to 35 acres, and this maintained a green feed source for the dairy throughout the year. Elephant grass pastures at Durant Strip held all the Angus breeders, and maintained them in excellent condition even while lactating. These paddocks were still carrying a beast to 1.75 acres in 1963, after four years' grazing.

Conservation of fodder is no longer practised for economic reasons and because the extension of improved pastures renders it unnecessary.

PAPUAN HIGHLANDS LIVESTOCK STATION, BISIANUMU

A description of the Station was given in the 1959-60 Annual Report. Rainfall data are shown in Appendix IV of this report. Development of the rain forest section continued with clearing and planting of improved pastures.

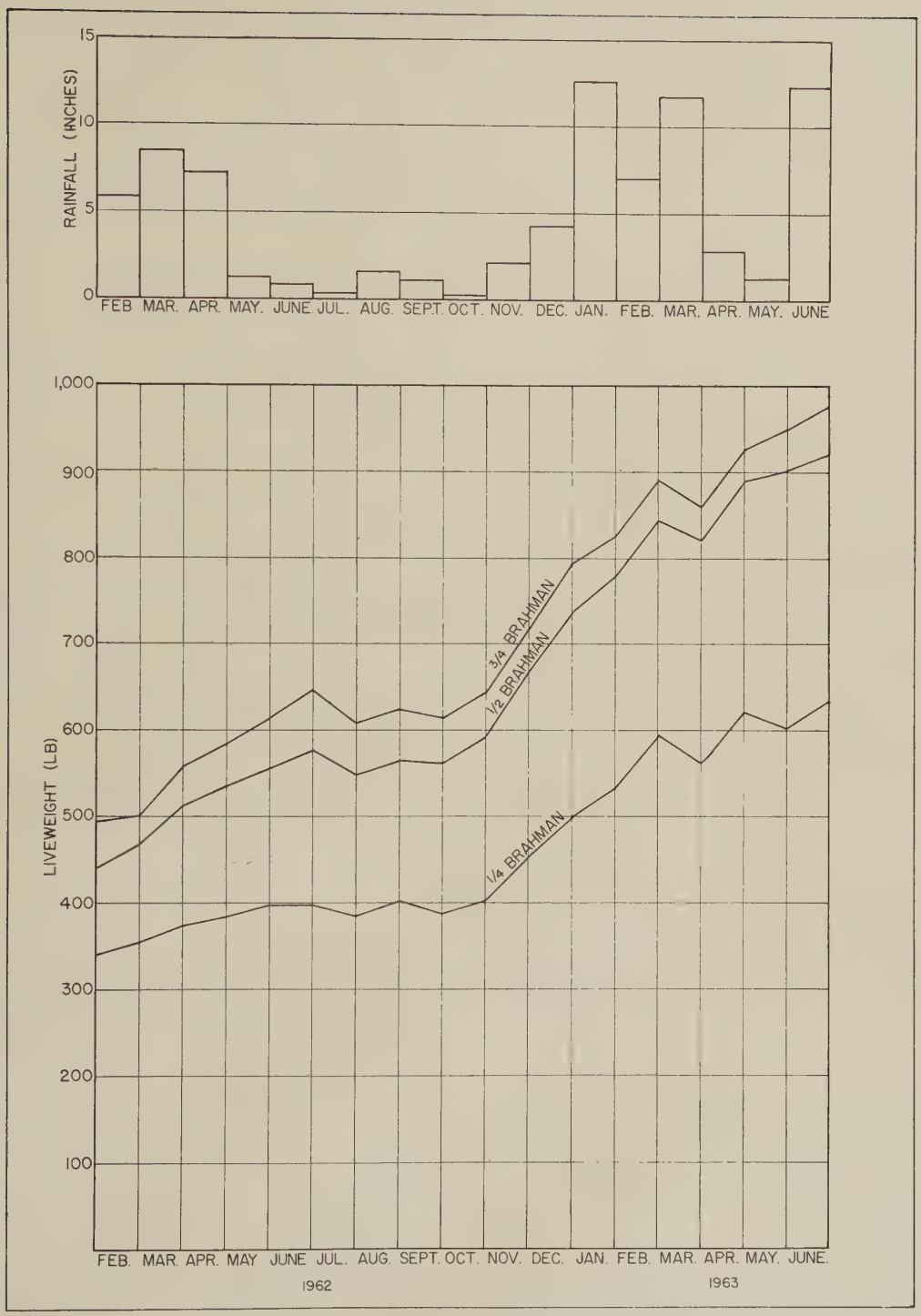

Figure 6: Comparative weights of quarter, half, and three-quarter Brahman-Angus calves at Moitaka, in relation to rainfall.

Cattle (Brahman)

The breeding performance of the stud Brahmans was improved by removal of calves for foster mothering on dairy cows at Moitaka, so as to avoid delays in the Brahman cows returning to oestrus. The breeding herd was increased by two heifers to thirteen females and one bull.

Cattle (Angus)

This herd produces replacement stock for the Moitaka Station. During 1961-62 a mating to Brahman bulls was made so as to obtain crossbred replacements.

Fifteen heifers were added in 1962-63 to increase the breeding group to 110 females. They were divided into two groups, one containing the younger, highest quality cows. Calving was only 26 per cent. in 1961-62, but 63 per cent. in 1962-63, compared with 74.5 per cent. in 1960-61. The irregularity may be explained by an extended calving interval, with a large drop of calves in June, 1961, and again in the early part of 1962-63. The overall low percentage reflects the age of many of the breeders.

Cattle (Red Poll)

A small herd of stud Red Poll cattle is grazed under untapped rubber. At June 1963, there were fifteen females and one bull, mostly fairly old. Six heifer calves were sold to cattle projects. One half-Brahman calf was born in 1962-63 and further matings with the Brahman bull were in progress.

Pasture Improvement

By June 1963, 285 acres were under improved pasture, principally *Axonopus compressus*, with some Guinea grass (*Panicum maximum*) and molasses grass (*Melinis minutiflora*). *Centrosema* is also used with both planted and natural grasses.

Eucalyptus suckers in some paddocks were cut and poisoned, giving about a 50 per cent. kill.

ANIMAL QUARANTINE STATION, KILA KILA

This station is the site of the Central Veterinary Laboratory, and provides quarantine facilities for animals imported into Papua. During 1961-63, renovations and improvements to laboratory facilities were carried out.

Livestock

Animals are kept mainly for experimental purposes, and included cattle, sheep, goats, pigs, horses, deer, chickens, rabbits and colonies of guinea pigs and mice. Imported day old chicks were also held at the Station to ten weeks of age before distribution to Agricultural Extension Stations for sale to village people.

Pasture Improvement

As most of the Station was formerly an airstrip, pasture establishment is difficult. Guinea, elephant and pangola grasses are established, all oversown with *Centrosema*. Pangola grass thrives in the wet season but fails in dry periods.

ANIMAL INDUSTRY CENTRE, THREE MILE, LAE

This Centre serves as a quarantine centre and as base for the District Veterinary Officer and Stock Inspector. During 1961-63, improvements were made to stockyards and labour quarters, and a poultry brooder house was built for the purpose of brooding day old chicks for village people.

Livestock

A small number of Jersey cattle are held for use in training livestock fieldworkers in procedures such as restraint, drenching and bleeding. The Centre is also used as a transit point for cattle and pigs sold to village people in the vicinity of Lae. The main livestock handled are those imported from Australia and held for quarantine observation. These numbered 484 cattle and 3 horses in 1961-62, and 977 cattle and 31 horses in 1962-63. While held at the Centre, cattle are sprayed as an added precaution against the reintroduction of tick to the area.

Day old chicks were imported and held for ten weeks prior to sale to village people.

Pasture Improvement

All the cleared area is under improved pasture consisting of a mixture of para, Guinea and elephant grasses with *Centrosema*, *Pueraria* and *Calopogonium*. Guinea grass areas were being extended as cattle do not trample it as much as they do para grass.

NEW GUINEA LOWLANDS LIVESTOCK STATION, ERAP

This Station was described in the 1959-60 Annual Report. Rainfall data are shown in Appendix IV of this report. During the period under review improvements were made to stockyards, including a spray race, steel crush and calf crush, weighbridge and slaughter floor. Two new bores were drilled, six new windmills and tanks were set up, and piping and troughs were installed to water fourteen paddocks. Twelve miles of fencing was erected. New labour quarters were also constructed.

Cattle

Because of consistently poor breeding performance of the Shorthorn cattle at Erap, the programme of selection for development of a type of Shorthorn which would thrive under local conditions has been discontinued. The use of Shorthorn bulls ceased in May 1963, and no further Shorthorn calves will be bred. As described above under "Veterinary Research" observations on Shorthorn cows showed many of them to be infertile, and 85 barren cows were sold by auction.

The main work on the station is now the Africander crossbreeding programme. Emphasis is being directed toward bringing the herd up to at least half Africander as soon as possible. Additional Africander-Shorthorn bulls were introduced from Australia in 1962-63, and 50 Brahman-Shorthorn cross heifers were purchased for breeding stock.

Calving averaged 19.6 per cent. in 1960-61, 21.7 per cent. in 1961-62 and 39 per cent. in 1962-63. The sale of barren cows in 1962-63 and use of increasing numbers of part Africander cows should bring a great improvement in future years.

Birthweight recordings made on calves with different proportions of Africander blood are shown in Table 28.

TABLE 28. BIRTHWEIGHT OF CALVES, NEW GUINEA LOWLANDS LIVESTOCK STATION, ERAP

Type of Calf	*No. of Animals*	*Average Birth Weight*	*Range*
		lb.	*lb.*
Shorthorn	8	55	30–64
¼ Africander	8	58	40–70
½ Africander	2	63	56–70
¾ Africander (imported *in utero*)	4	72	64–80

The Station remained free from cattle tick and brucellosis, and no positive tuberculosis reactors were detected after October 1962.

Pigs

Breeding with stud and grade Berkshire pigs continued. In 1961-62, 71 piglets were born in 9 litters, making an average of 7.9 piglets per litter. In 1962-63, 162 piglets in 20 litters gave an average of 8.1 piglets per litter. Post-natal losses were heavy, and an analysis of causes of death of piglets is presented in Table 29.

TABLE 29. CAUSES OF DEATH IN PIGLETS, NEW GUINEA LOWLANDS LIVESTOCK STATION, ERAP

Year	*Piglets Born*	*Stillborn or Died Soon after Birth*	*Overlying*	*Other Causes*	*Piglets Weaned*
1960–61	152	18 (45%)*	18 (45%)	4 (10%)	112
1961–62	71	13 (65%)	3 (15%)	4 (20%)	51
1962–63	162	16 (26%)	9 (14%)	37 (60%)	100

* Figures in brackets are percentages of total deaths.

Losses from overlying were lower in 1961-63 with the use of circular farrowing pens.

The best results were produced by young station-bred sows, and most weak piglets were born to the original imported sows which were five years old by 1963. Improvement in numbers of litters in 1962-63 resulted from the pigs being exercised in pasture morning and evening.

In an attempt to explain poor breeding of some animals, sera were taken for brucellosis agglutination testing. All gave negative reactions.

Forty-eight weaner pigs were sold in 1961-62, and 72 in 1962-63, mainly to New Guinean purchasers.

Horses

Seven foals were born during 1961-62 to the part Macassar stallion which was later sent to West New Guinea. No foals were born in 1962-63. An imported stallion, "Mulvi", arrived from Rabaul in April 1963, but being in poor condition after the voyage he was wormed and hand fed before serving mares.

Nine horses walked down from Baiyer River in June 1962, were sold to local graziers.

Three deaths from "Markham Valley Horse Disease" occurred in 1961-62, but no deaths occurred in 1962-63.

Donkeys

The interest of the people of the upper Erap Valley in use of donkeys as pack animals has waned. To prevent excess build up in numbers, all adult males were castrated. Four animals were sold to European settlers.

Pastures and Crops

In 1961-62, 104 acres were planted to improved pastures and 112 acres in 1962-63. By June 1963, there were 284 acres of improved pasture, consisting of 73 acres elephant grass, 193 acres Guinea grass, 17 acres buffel grass, and 1 acre of molasses

grass. The last is undesirable because of high fire risk. Guinea grass did not generally establish satisfactorily from seed, so is now established by tussocks planted behind a mould-board plough. Some rows of *Leucaena glauca* were sown in elephant grass for observation, but did not do well initially because of dry weather.

Most cattle on the station were run on unimproved natural pastures, in which the dominant species were kangaroo grass (*Themeda* sp.) and kunai (*Imperata cylindrica*). Kangaroo grass is very palatable and in paddocks where a mixed pasture is available cattle selectively graze it. It is the predominant species on gravel soils. Overgrazing of these areas results in rapid invasion by weeds such as *Sida rhombifolia*.

Sorghum and maize were grown for pig food. Because of high insect damage to maize, sorghum is now preferred.

ANIMAL INDUSTRY CENTRE, GOROKA

Development was concentrated on the site four miles west of Goroka, although in 1961-62 some cattle were still run on the area adjacent to the town. Rainfall data are shown in Appendix IV.

During the two years, the piggery was extended to include 86 pens. Each pen consists of a ten foot square covered area and an open space (*see* Plate 5). All have concrete floors, walls of arc mesh, marsden matting or river stone, and galvanised iron roofs. Divisions between pens are made of marsden matting welded to steel pickets. Circular farrowing pens are included. A new dairy and stockyards were also built, both on concrete floors, and improvements were made to the water reticulation system.

Cattle

A herd of Australian Illawarra Shorthorns is maintained primarily for producing bulls for cattle projects. Cows are hand milked, once daily, to instruct cattle project trainees and at the same time to allow calves sufficient milk for rapid growth.

One tuberculosis reactor was detected and slaughtered in 1962-63; subsequent tests were negative.

Pigs

Stud Berkshires are run under fairly intensive conditions. Two native crossbred sows were also included in the herd, being used to produce young pigs for experiments on anthrax.

There was a steady improvement in number of litters and litter size over the last three years, as shown in Table 30.

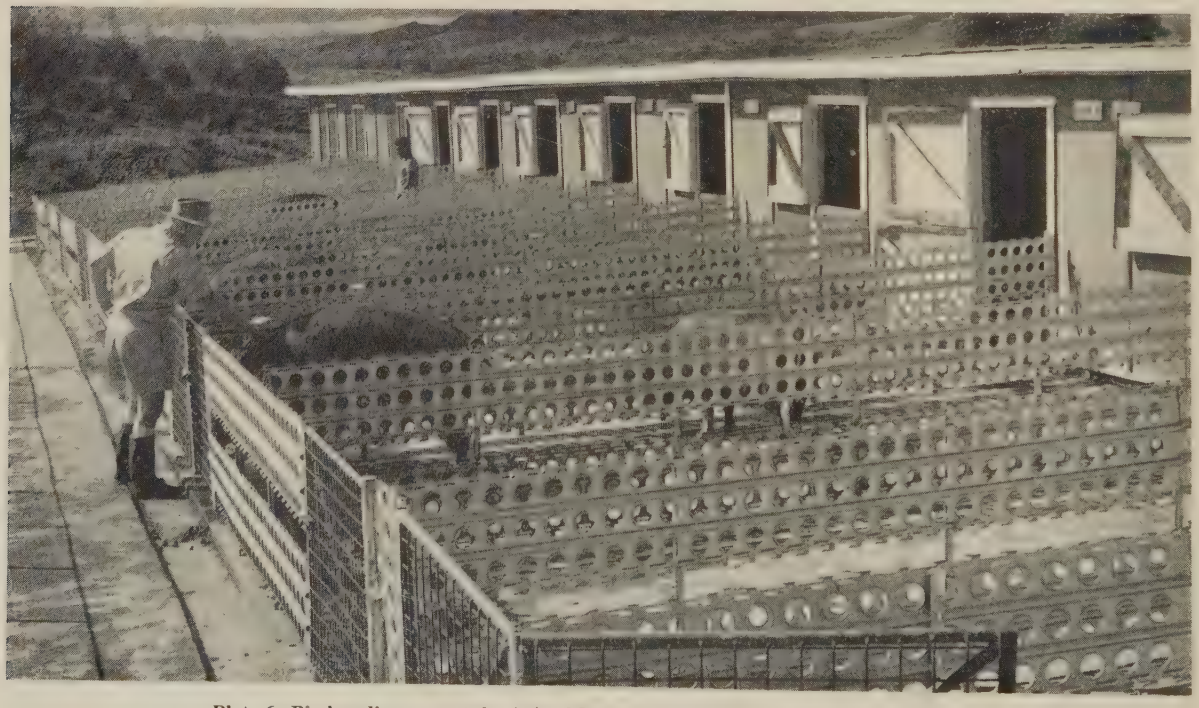

Plate 6. Pig breeding pens at the Animal Industry Centre, Goroka. (*Photo: D.I.E.S.*)

TABLE 30. PIGLET PRODUCTION, ANIMAL INDUSTRY CENTRE, GOROKA

——	1960–61	1961–62	1962–63
Number of Litters.. ..	33	39	48
Number of piglets born ..	165	201	262
Average litter size ..	5.00	5.21	5.36

The increases are attributed to culling of the breeding stock, which involved disposing of any sow not producing fifteen piglets over three successive litters, and to a system of rotation of the sows. Sows move to one pen for mating, to another for gestation, to another for farrowing and then back to the mating pen after the litter is weaned. Post-natal death rate was low, being only 7.5 per cent. in 1961-62.

Boars are lent to villagers for periods of up to three weeks, and then returned to the station for high quality feeding before loan to another village. There is a keen demand for culled pigs for feasts and celebrations, but these are refused as the aim is to encourage villagers to rear their own pigs.

So far as possible, pigs are fed on locally produced foodstuffs. High protein meals and mineral foodstuffs are imported but grain and other carbohydrate sources such as sweet potato are produced locally. Much sorghum is obtained from the Baiyer River Livestock Station.

One hundred and sixty pigs were distributed in 1961-62, and 151 in 1962-63.

Pastures and Crops

Cattle on native pastures fall away at periods when the soil is too dry or too wet. Carrying capacity is one beast to four acres.

Thirty acres at the Centre is planted to elephant grass and six acres to para grass. The former is the better grass for Goroka conditions, and recovers well from grazing. The 36 acres of improved pasture carried an average of 24 adult cattle throughout 1961-62.

Eleven acres of sweet potato were grown in 1961-62, and twelve acres in 1962-63.

WESTERN HIGHLANDS LIVESTOCK STATION, BAIYER RIVER

A description of the station was given in the 1959-60 Annual Report. Rainfall data are shown in Appendix IV of this report. The Station produces the bulk of the cattle for Native cattle projects in the Highlands, and also produces part Africander females for the Erap breeding project.

Cattle

The majority of the cattle on the Station are Poll Shorthorns, but with the introduction of two Africander-Shorthorn F_1 bulls in 1960-61, a number of quarter Africander calves were dropped in 1961-62 and 1962-63.

The breeding herd joined in October 1960, was 460 head, of which 17 died before calving. Of 337 calves born, 17 died before branding. Thus calving percentage was 76.1 per cent. and branding percentage 72.2 per cent. From the 1961 mating, 330 calves were born to 455 cows, giving 72.5 per cent. calving. Calves were weaned between 7 and 9 months of age, and after drenching with "Neguvon" were run on improved pasture.

The Africander cross bulls were mated at 2 per cent. as against 4 per cent. for the Shorthorns. In 1961-62, 116 cows produced 95 calves (82 per cent.) of which unfortunately only 34 were females and 61 males, including one set of twins. In 1962-63, these bulls sired 72 per cent. calves. The quarter Africander animals showed advantages over their Shorthorn contemporaries in coat type and in general thriftiness and well-being. Four Poll Shorthorn bulls were imported from Australia in 1961-62, and one Africander bull in 1962-63. However, there will be a shortage of bulls in the coming year, with 800 cows to be covered and 15 bulls available; 32 would be necessary to give the desired 4 per cent. mating.

In 1961-62, one steer gave a suspicious reaction to tuberculosis testing, but on slaughter showed no visible lesions. Tuberculosis and brucellosis tests in 1962-63 were all negative. An outbreak of "pink eye" type ophthalmia occurred, but only one beast lost its sight. This could have been a manifestation of infectious bovine rhino-tracheitis. A foot rot condition was controlled by installation of a copper sulphate foot bath.

Horses

The station horses were maintained in better condition with supplementary feeding. Despite injuries to the stallion "High Adventure" he sired 22 foals.

Pastures and Crops

During the two years, 900 acres were planted to improved pastures, bringing the total area to 1,500 acres. This consists of approximately 1,100 acres of elephant grass and 400 acres of Guinea grass, with some para grass in low lying damp areas. In

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addition, some four tons of molasses grass and *Stylosanthes gracilis* seed has been broadcast in recent years over the remaining 13,500 acres of grazing land. These species are now quite well established, and the carrying capacity of the natural pastures has been improved.

Suitable legumes pose a problem on the Station. As well as *Stylosanthes*, centro (*Centrosema pubescens*), phasey bean (*Phaseolus lathyroides*) and glycine (*Glycine javanica*) show some promise.

Twenty-five tons of sorghum were harvested during the period, for use at the Animal Industry Centre, Goroka.

ANIMAL INDUSTRY CENTRE, KURAKAKAUL

A description of the Centre was given in the 1960-61 Annual Report. Rainfall data are shown in Appendix IV of this report. Capital improvements during the past two years included the completion of two new eight-pen piggery blocks, all with concrete floors, walls of steel pipe, steel pickets and marsden matting, and roofs of galvanized iron. Stockyards were renovated, additions made to the dairy, and water reticulation improved. A workshop for the Regional Mechanic was constructed.

Cattle

Selection for milk production is being carried out in the grade Jersey herd. No further action was possible on the proposed introduction of Sahiwal and Sindhi crossbred cattle because of disease conditions in the Australian herd. Introduction of these breeds will be made through importation of semen when a small artificial insemination centre has been established in the Territory.

In 1961-62, 58 calves were born from a breeding herd of 85 cows (68.2 per cent. calving). In 1962-63, calving was 80 per cent. Calves are taken from their mothers at 48 hours and raised on a concrete floored calf pen, being fed whole milk from the dairy. They are turned out to graze at six months after being fed grass *ad lib* in the calf pen. Bulls are kept in isolation in three bull paddocks, and cows are taken to these pens when oestrus is observed as they go through the dairy.

Lactation records on 23 cows were taken for the first time in 1961-62. This was the first time that many of the aged cows had been through a machine dairy and lactations were very low. Lactation period ranged from 14 to 355 days, and production ranged from 50 to 3,550 lb. of milk. Production level was so poor on the average that the initial culling level was set at only 400 lb. of milk.

In 1962-63, 53 cows and heifers were tested and gave a better performance. An average lactation length of 248 days and average production of 1,820.2 lb. of milk was obtained after culling all cows producing less than 1,500 lb. of milk.

Pigs

Pig breeding results in 1961-62 were poor, when overfeeding resulted in lowered fertility and only five litters were produced. Non-breeders were culled and seven young gilts were retained as future breeders. Better results were obtained in 1962-63, when 14 litters were born. Breeding results over three years are summarized in Table 31.

TABLE 31. PIGLET PRODUCTION, ANIMAL INDUSTRY CENTRE, KURAKAKAUL

—	*1960–61*	*1961–62*	*1962–63*
Number of litters ..	6	5	14
Number of piglets born ..	56	33	102
Average litter size ..	9.3	6.6	7.3

Of piglets born in 1962-63, 83 per cent. were reared to weaning.

Horses

Stallion "Mulvi" was transferred to Erap in April 1963. "Prince Gaekwar" went down with an enteric disease which was not controlled until the source of infection was traced to the stable hand tending him. He sired ten foals out of station mares, and also served a number of privately owned mares.

Pasture Improvement

The whole area of the station suitable for pasture improvement has been planted, leaving about 100 acres which is too steep to be cultivated for pasture planting. In the abnormally dry period of January to March 1963, some 40 acres of improved pasture died out. This left 160 acres of Guinea grass, 16 acres of elephant grass and 4 acres of buffel grass. *Centrosema* and *Pueraria* occur throughout most of the improved and unimproved pastures. Weed control in the improved pastures is a major problem, as selective grazing of the introduced species allows weeds to predominate unless constant attention is given to weed control.

CATTLE STATISTICS

Cattle statistics for Papua and New Guinea are shown in Table 32.

TABLE 32. CATTLE POPULATION, TERRITORY OF PAPUA AND NEW GUINEA

District	*30th June 1961*	*30th June 1962*	*1961–62 Increase*	*30th June 1963*	*1962–63 Increase*
Central	3,897	4,602	705	5,070	468
Northern	872	997	125	1,240	243
Milne Bay	550	570	20	887	317
Gulf	126	120	−6	130	10
Western	69	99	30	104	5
Southern Highlands	59	59	0	67	8
Total—Papua	5,573	6,447	874	7,498	1,051
Morobe	6,462	8,675	2,213	10,614	1,939
Madang	2,259	2,340	81	3,483	1,143
Eastern Highlands	1,436	1,863	427	2,288	425
Western Highlands	2,151	2,117	−34	2,254	137
Sepik	465	559	94	850	291
Manus	160	165	5	170	5
New Britain	1,143	1,403	260	997	−406
New Ireland	450	643	193	764	121
Bougainville	114	124	10	95	−29
Total—New Guinea	14,640	17,889	3,249	21,515	3,626
Total	20,213	24,336	4,123	29,013	4,677

DIVISION OF PLANT INDUSTRY

The research programme of the Division continued actively over the two year period and laboratory and quarantine services were provided. The work is described under the reports of the Experiment Stations and the Technical Sections (Plant Introduction and Quarantine, Plant Pathology, Economic Entomology, Agricultural Chemistry and Soil Survey).

Identification of Experiments

During the period under review, a uniform system of numbering experiments was introduced at all Plant Industry stations. The numbering system includes letters to identify the location of the experiment and the crop plant or type of experiment. The first letter identifies location, thus:

- A Aiyura, Highlands Agricultural Experiment Station.
- B Bubia, Plant Industry Centre.
- Bi Bisianumu, Rubber Section.
- E Epo, Agricultural Experiment Station.
- K Keravat, Lowlands Agricultural Experiment Station.
- T Territory, used for coconut experiments on plantations throughout the Territory.

The remaining letters identify the crop plant, or indicate the subject of the experiment when no single crop is involved.

- AH *Arachis hypogaea* (peanut)
- AO *Anacardium occidentale* (cashew nut)
- AS *Agave sisalana* (sisal)
- CA *Coffea arabica* (arabica coffee)
- CC *Coffea canephora* (robusta coffee)
- CD *Curcuma domestica* (turmeric)
- CF *Cymbopogon flexuosus* and *C. citratus* (lemon grass)
- CN *Cocos nucifera* (coconut)
- EG *Elaeis guineensis* (oil palm)
- EN Entomological
- GH *Gossypium hirsutum* (cotton)
- GM *Glycine max* (soya bean)
- HB *Hevea brasiliensis* (rubber)
- HC *Hibiscus cannabinus* (kenaf)
- IB *Ipomoea batatas* (sweet potato)
- LG *Leucaena glauca*
- MT *Musa textilis* (Manila hemp)
- NT *Nicotiana tabacum* (tobacco)
- OS *Oryza sativa* (rice)
- PA Pastures
- PC *Pyrethrum* (*Chrysanthemum*) *cinerariaefolium*
- PN *Piper nigrum* (pepper)
- RC *Ricinus communis* (castor-oil)
- SF Soils and fertilizers
- SV *Sorghum vulgare* (sorghum)
- TC *Theobroma cacao*
- VP *Vanilla planifolia*
- WC Weed control
- ZO *Zingiber officinale* (ginger)
- ZM *Zea mays* (maize)

Numbers are then used to identify individual experiments, the order being more or less chronological.

Experimental Design and Analysis

The Department is extremely fortunate in that the Commonwealth Scientific and Industrial Research Organisation makes available the services of Mr. G. A. McIntyre, Senior Principal Research Officer with the Division of Mathematical Statistics, Canberra, to advise on all aspects of experimental design. Mr. McIntyre visits the experiment stations every two years, his last visit being in mid 1961; another visit is planned for July 1963. During these visits Mr. McIntyre inspects field experiments and discusses design and analysis with officers concerned. Most of the experiments reported here were designed by Mr. McIntyre after discussion with local staff, and he also carried out most of the statistical analyses of the results.

LOWLANDS AGRICULTURAL EXPERIMENT STATION, KERAVAT

This is the major low-altitude experiment station in Papua and New Guinea, and is located in the Gazelle Peninsula of New Britain, the most intensively developed area of the Territory. A description and plan of the station were given in the 1959-60 Annual Report. Rainfall and sunshine data are shown in Appendix IV of this report.

CACAO

CACAO BREEDING

Progeny Trials

Blocks 304 *and* 305: No further work has been carried out in either of these blocks.

Block 405, *KTC*2: Yields are recorded as numbers of pods from each tree at each harvest. These records have been totalled and converted to pounds dry cocoa per acre, using pod values (as determined in 1960-61). Results are summarized in Table 33. Mean yield of the block as a whole was 1,248 lb. in 1961-62 and 1,540 lb. in 1962-63 (dry cocoa per acre).

TABLE 33. KTC2 CACAO PROGENY TRIAL, BLOCK 405, KERAVAT

YIELDS CONVERTED TO LB. DRY COCOA PER ACRE

Parent	*Percentage Deaths at June 1962*	*Pod Value*	*Yield 1961–62*	*Yield 1962–63*	*Mean Yield 1953–63*
K6 ..	2	9.3	2,349	2,726	1,871
K12 ..	6	10.5	1,865	2,206	1,415
K23 ..	7	10.6	1,417	1,863	1,386
K25 ..	8	9.5	1,339	1,478	1,299
K13 ..	8	10.8	1,640	2,032	1,253
K19 ..	4	12.0	1,550	1,992	1,196
K26 ..	13	9.1	1,242	1,662	1,185
K20 ..	6	10.7	1,304	1,788	1,155
K24 ..	6	9.0	1,375	1,701	1,144
K17 ..	1	10.9	1,243	1,508	1,106
K11 ..	16	11.2	1,165	1,415	1,067
K16 ..	6	10.6	1,348	1,524	1,051
K27 ..	3	9.2	1,160	1,485	1,022
K5 ..	6	11.8	934	1,050	1,018
K21 ..	12	10.2	981	1,307	938
K14 ..	9	9.7	842	1,018	884
K9 ..	16	10.4	723	784	819
K10	32	11.4	610	763	458

Table 33 also shows the percentage deaths in each progeny up to June 1962. By June 1963, another 76 trees had died, many as a result of dieback, bringing the total to 11 per cent. Compared with Block 506 (KTC3) mortality has been lower, but of the progenies common to both blocks the relative proportions of deaths have been similar, with K26 highest. K10 in Block 405 shows a much higher proportion of deaths than K26, and it is probable that this parent either carried deleterious genes or was an inbred, as very many of its progeny were weak and stunted from their earliest growth.

The shade-fertilizer trial superimposed on this block is discussed under *Cacao Agronomy*.

Block 506, *KTC*3: A summary of progeny yields in this trial is given in Table 34, together with the pod values for each progeny as determined in 1960-61.

Table 35 shows yields of the progenies at 12 ft. and 15 ft. spacing in 1961-62 and 1962-63. These results suggest that there may be some differences between progenies in their response to spacing.

TABLE 35. KTC3 CACAO PROGENY TRIAL

GIRTHS AND YIELDS (LB. DRY COCOA PER ACRE) AT 12 FT. AND 15 FT. SPACING

Progeny	*Average girth (in.) Feb. 1963*	*1961–62*		*1962–63*	
		12 ft.	*15 ft.*	*12 ft.*	*15 ft.*
K23 ..	18.7	1,098	1,039	1,476	1,237
K24 ..	20.4	1,129	1,176	1,526	1,360
K25 ..	19.7	1,403	1,236	1,687	1,480
K26 ..	20.8	825	538	1,148	849
K27 ..	20.9	765	854	1,287	1,353
K28 ..	21.0	1,209	1,352	1,649	1,913
K29 ..	22.3	1,774	1,942	2,497	2,475
K30 ..	21.1	1,299	1,311	1,657	1,719
K31 ..	18.9	758	1,207	1,087	1,778
K32 ..	20.6	943	1,215	1,489	1,873
Mean ..	..	1,120	1,187	1,550	1,604

TABLE 34. KTC3 CACAO PROGENY TRIAL

PROGENY YIELDS CONVERTED TO PODS PER ACRE 1953–54 TO 1962–63

Year	*K23*	*K24*	*K25*	*K26*	*K27*	*K28*	*K29*	*K30*	*K31*	*K32*	*Mean*
1953–54	11,861	3,173	10,278	5,927	2,829	6,619	6,394	6,552	6,800	5,666	6,610
1954–55	14,386	7,978	12,950	8,908	6,465	11,431	12,798	12,433	12,815	11,636	11,180
1955–56	11,824	6,549	11,294	6,421	6,913	9,661	10,207	11,258	9,743	7,789	9,166
1956–57	19,262	13,375	17,612	12,802	10,443	16,636	18,019	15,335	14,692	16,321	15,450
1957–58	10,986	7,795	11,032	6,828	6,648	10,782	10,654	12,311	7,709	8,582	9,333
1958–59	16,643	12,319	16,454	10,604	8,920	14,878	18,088	16,117	9,654	13,206	13,688
1959–60	18,230	14,766	20,538	12,623	12,909	18,769	21,645	22,831	13,199	16,712	17,222
1960–61	12,058	11,566	13,166	7,674	7,990	13,395	17,519	17,621	9,949	11,948	12,289
1961–62	12,928	11,408	12,911	8,265	7,659	13,566	19,690	16,572	10,019	11,221	12,424
1962–63	16,105	14,107	15,620	11,785	12,616	19,186	26,579	21,539	15,382	17,919	17,084
Mean	14,428	10,304	14,185	9,184	8,339	13,493	16,160	15,257	10,996	12,100	..
Pod Value	12.1	9.9	10.0	12.2	9.5	10.6	10.7	12.7	10.2	10.4	..
Mean lb. per acre ..	1,192	1,041	1,418	753	878	1,273	1,510	1,201	1,078	1,163	..

Average girths of each progeny as measured in February 1963, are also shown in Table 35. It is of interest to note that K23 and K25, which gave highest yields in the first years of bearing but subsequently declined, are relatively non-vigorous, in contrast to K29 which came to the fore in later years.

Further deaths were recorded in all progenies, and at 30th June 1963 percentages were:

K23—16.5
K24—13.0
K25—17.5
K26—31.5
K27—13.5
K28—10.5
K29—4.5
K30—3.0
K31—8.5
K32—10.0

Other aspects of the trial in this block (shade, spacing, and fertilizer observations) are discussed under *Cacao Agronomy*.

Blocks 106, 107, 108, 3010: These blocks contain progenies of hand pollinations of selected mother trees, both self and cross pollinations. In some cases the seedlings are second generation inbreds, and many of these show extreme loss of vigour, frequently complete dwarfing and failure to flower.

Clonal Seed Gardens (*Blocks* 209 *and* 308)

Seed supplied to growers comes mainly from these blocks, though an appreciable quantity is taken also from the self-incompatible clones in the Clone Testing Trials. Recent results in the Pollen Dispersal Trials indicate that male parentage in all cases would be mixed, and seed from the Clone Testing Trials should be as good as that from the Clonal Seed Gardens.

Tests carried out early in 1963 showed that a number of clones previously thought to be self-incompatible were actually self-compatible (viz. K11, KA2.101, KA5.103, K23.103). Further tests are being made to check all clones classified as self-incompatible, and any found to be self-compatible will no longer be used as a source of seed. The main feature of seed at present supplied is that it is taken from self-incompatible trees and therefore would not be inbred.

Demand for seed continued to be heavy, and frequently there were delays in filling orders. All reports on its performance have been favourable.

KTC5, Clone Testing Trials

Design of these trials was described in the 1960-61 Annual Report. It was stated then that one aspect would be a study of the influence of male parentage on flavour and cocoa butter content by comparison between the same self-incompatible clones with different pollinators in the four replicates of each series. Information from the Pollen Dispersal Trials now indicates that there would be a very appreciable influence from pollinators other than the immediate surround, so this aspect of the trials will need to be reappraised.

All series are now bearing, but yields from series IV, V and VI were not very substantial. Total yields for series I, II, and III, up to March 1963, are shown in Table 36.

TABLE 36. KTC5 CACAO CLONE TESTING TRIALS, SERIES I, II, AND III

YIELDS UP TO 31ST MARCH, 1963 (LB. DRY COCOA PER ACRE)

Series I (Planted March 1956)		*Series II (Planted March 1957)*		*Series III (Planted November 1957)*	
Self-Incompatibles		*Self-Incompatibles*		*Self-Incompatibles*	
KA5.104	6,650	K20 ..	5,141	KA5.104	2,302
K27.102..	4,506	K6.101 ..	4,345	K23.103*	2,038
K24.103..	4,365	K27.102..	3,263	K23 ..	1,637
K16.101..	4,319	K25.102..	2,815	KA5.103*	1,485
K21 ..	4,195	K23.106..	2,527	KA2.102	1,254
KA2.105	4,070	K4 ..	2,468	K28 ..	1,106
K11.101..	3,627	K19.101..	2,255	KA2.106	838
K12.101..	2,179	K16 ..	1,692	K3 ..	696
K23.105..	2,105	K15.101..	591	KA10.101	540
Mean ..	4,002	Mean ..	2,789	Mean ..	1,322
Self-Compatibles		*Self-Compatibles*		*Self-Compatibles*	
K50 ..	5,322	KT82 ..	3,428	K5 ..	1,076
KT82 ..	3,527	K5 ..	2,833	K28.101..	1,039
K5 ..	2,985	K23.107..	1,675	K23.101..	789
K52 ..	1,045	K1.103 ..	878	K1.102 ..	..
Mean ..	3,220	Mean ..	2,204	Mean .. (excluding K1.102)	968

* These clones have now been shown to be self-compatible.

No yield is shown in Table 36 for K1.102 in series III, as this clone was almost eliminated by dieback, and by 1963 it had virtually ceased to bear. Yields shown in the table were converted from

pod numbers per plot to yields of dry cocoa per acre using pod value determinations made to date; as these pod values are subject to revision, the yield figures may later be adjusted slightly.

On the basis of yields to the end of March, 1963, the following clones were selected for propagation and distribution to planters:

Self-Incompatible	*Self-Compatible*
K20	K11
K25	K50
K32	KT82
K6.101	K17.101
K24.102	K23.102
K24.103	K23.103
KA2.105	K25.101
KA5.101	KA2.101
KA5.104	

Nine of these were selected from series IV and V (both planted from July, 1958 onwards) on the basis of early performance relative to K5, which is the bridging clone between all series.

Tests in 1963 showed that four clones planted as self-incompatibles (viz. K11, KA5.103, K23.103, and KA2.101) were in fact self-compatible. This should not affect the validity of the assessment of yield, although their presence would complicate the pattern of pollination of self-incompatibles.

A number of "foreign" trees were detected throughout the trials and a tree-by-tree check was initiated. Identification was based on pod characters (size, shape, degree of furrowing and warting, colour, etc.). In series I, to the end of June, 1963, nine foreign trees were detected, but as well as these there were 10 replants and 63 other trees whose identity could not be checked because they were not bearing pods. Of the nine foreign trees, only one dated from the original planting, the other eight being replacements made in 1957. In Series IV, all 24 trees planted as K6 were found to be a single clone but definitely not K6. The clone could not be positively identified, so was designated K6A.

In the earlier planted series, total yields of all self-incompatible clones varied markedly between replications. This was thought at first to result from variation in pollination effectiveness of the self-compatibles. However, inspection of the heights of the various clones showed that the differences were probably effects of competition. For example, in Series I the self-incompatible plots stand out as more vigorous than the surrounds in replicates 3 and 4, while in replicates 1 and 2 they are similar in vigour. The order of replicate yields for the year ending March 1963 was 3 (2,252 pods), 4 (2,233 pods), 2 (1,776 pods), and 1 (1,663 pods). In Series II also yields of self-incompatibles were lower in replicates with more vigorous surrounds.

Effect of competition on the less vigorous self-incompatible clones was pronounced. For example, yields of two self-incompatible clones (total pod numbers from 24 trees of each) were as follows—

Clone	*1961–62*	*1962–63*
K23.105 ..	972	214
K12.101 ..	1,103	313

Both of these clones were being overgrown by the surrounds in all replicates.

Pod values were determined for all clones except K1.102 in Series I, II and III. Clones in Series IV, V and VI will be evaluated as soon as sufficient pods are available. Several determinations have now been made on some clones in the earlier series, and these showed appreciable variation between different determinations. It was therefore decided to repeat the determinations every six months so far as possible. Results from a number of determinations on K5 in Series I showed a higher pod value (i.e. smaller pod) in the first tests, and a fairly steady improvement in pod size as the trees aged. No similar trend was found with any other clone, and pod size comparisons between K5 in all series did not support the conclusion that pod size was influenced by age, so the effect was probably only chance.

Samples used in pod value determinations were forwarded to Cadbury-Fry-Pascall who very kindly gave assessments of skin percentage, fat percentage and flavour. These factors will be taken into account in clone selection and breeding work, but the need was felt for more information on variability between samples from the same clone. Accordingly, samples were taken from Series I in September 1962 and April 1963 for determination of cocoa butter content by the Chemistry Section. The first aim was to assess variation from pod to pod within the same tree, and between trees of the same clone, as a guide to sampling method for obtaining an accurate index of the clone's cocoa butter content. A complicating factor is the influence, if any, of the male parent. Results to date have shown wide variation within a single clone, both in self-compatibles and

self-incompatibles. Three of the four surrounds in Series I showed approximately the same mean fat content in figures available to date (see Table 37.).

TABLE 37. KTC5 CACAO CLONE TESTING TRIALS

SERIES I SURROUNDS: COCOA BUTTER CONTENT

Clone	*No. of Samples*	*Mean Fat*	*Range*
		Per cent.	*Per cent.*
K5	5	53.5	50.4–54.9
K50	3	56.1	55.4–57.0
KT82	4	56.5	54.0–57.8
K52	5	56.6	55.5–57.1

In 1962, *Botryodiplodia* dieback showed up in the trials, where it was first noted seriously attacking the self-compatible surround clone K1.102 in Series III. This was pruned heavily and other clones in Series III were pruned as necessary, mainly in the incompatible plots within the K1.102 surround. The disease continued to spread and a further three prunings were made of all series, although very little was found in Series VI which is separated from the others, in Block 3010. Differences were seen between clones in their susceptibility to the disease, and it was interesting to note in series IV that KA2.1012 appeared very susceptible while KA2.101 appeared fairly resistant. These are first generation progeny of the same parent tree (KA2). In addition to pruning, the trees were fertilized with NPK mixture to aid recovery, and by June 1963 the situation was improving. Many trees of K1.102 had died and probably more will die, as evidence of infection was still visible. Despite this, yields of the self incompatible plots in this replicate were normal, so that pollen could not have been limiting. However, plots were not being subjected to normal competition and this would tend to boost yields.

KTC8. Hybrid Seed Development—Block 309

All seed for this trial had to be produced by hand-pollination, and because of factors such as variable flowering of the parent trees it was impossible to obtain sufficient seed from all crosses to plant all trees simultaneously. Most of the seedlings were transplanted from the nursery in November 1959, but there was a delay of up to twelve months, and occasionally longer in completing field planting. This causes some difficulty in interpretation of early yield results, although the differences should be evened out after a few years' bearing. Initial assessments have been based on yields of trees in the first three or three and a half years since transplanting, but this would not give fully comparable yield figures since different planting dates would result in some differences in growing conditions.

Growth of seedlings was generally very satisfactory, and the first pod was harvested in January 1962, with a total of 27 pods produced by June 1962. In the following year a large proportion of the trees commenced to bear and production was fairly substantial. *Botryodiplodia* dieback affected a number of trees, mainly at the north-western end of the block, adjacent to the Clonal Seed Garden in Block 308 where there was a heavy dieback incidence. The attack necessitated the stumping of a few trees and pruning of some others.

In May 1962, a number of crosses were selected on the basis of progeny vigour and early bearing for establishment of hybrid seed gardens. In May 1963, further examination of the progenies which had reached 3½ years of age led to the discarding of two of the crosses selected earlier and addition of some others. By June 1963, seed gardens for the following crosses had been wholly or partly established; K23 x KT74, KT275 x KT74, KT8 x KT82, KT8 x KT188, K4 x KT173, KT193 x KT172. The design of the seed gardens was varied in the light of new information from spacing and Pollen Dispersal Trials, so that few of them follow the layout shown in the 1960-61 Annual Report. In the earliest gardens hedge plantings of 18 ft. x 6 ft. were used, but in later gardens a square or near-square rectangular spacing was favoured.

Fifteen of the 48 progenies in the trial were fully planted out in November 1959. To the age of 3½ years, the best yield was obtained from KT8 x KT188 progeny, which produced 1,215 pods from the 48 trees. This is equivalent to approximately 470 lb. per acre at the trial spacing of 15 ft. x 15 ft. At the standard spacing of 12 ft. triangle this would have represented about 700 lb. dry cocoa per acre.

All except four (KT285 x K1.103, KT193 x KT145, KT203 x KT73 and KT203 x KT160) of the 48 progenies had borne pods in at least one replicate by the age of three years. Of the best twenty, ten were from like crosses (Criollo x Criollo or Forastero x Forastero) and ten were from unlike crosses (C x F or F x C). These included progenies of both crosses involving KT202, KT8, KA2.105, and KT297 as female parents and KT138, KT82, K50, KT172, KT293 and KT290 as male parents.

Yields of progenies from the six groups of four crosses in which these parents occur are shown in Table 38.

TABLE 38. KTC8 CACAO HYBRID SEED DEVELOPMENT

POD NUMBERS TO AGE 3 YEARS OF 24 PROGENIES

Cross	*Type*	*Pod Numbers*
KT202 x K50	F x F	161
KT202 x KT138	F x C	317
KA2.105 x K50	C x F	101
KA2.105 x KT138 ..	C x C	213
KT291 x KT82	F x F	76
KT291 x KT188	F x C	18
KT8 x KT82	C x F	253
KT8 x KT188	C x C	259
K30 x KT74	F x F	6
K30 x KT181	F x C	43
KT297 x KT74	C x F	175
KT297 x KT181	C x C	175
KT170 x KT172	F x F	128
KT170 x KT145	F x C	42
KT193 x KT172	C x F	88
KT193 x KT145	C x C	0
K19 x K27	F x F	6
K19 x KT293	F x C	94
KA2.1012 x K27	C x F	20
KA2.1012 x KT293 ..	C x C	104
K6 x K4.101	F x F	54
K6 x KT290	F x C	88
K25 x K4.101	C x F	70
K25 x KT290	C x C	85

In the progeny yields quoted in Table 38, the total pod number from unlike crosses is 1,309, and from like crosses 1,267. The difference is slight and does not indicate any hybrid vigour in unlike crosses. While it is too soon to be dogmatic, one would expect hybrid vigour to express itself in earliness of bearing. Its failure to appear in this trial may be because the parents chosen as Criollo and Forastero were not really genetic extremes. The parents were all selected from a Trinitario population, and classified mainly on bean colour and pod characters. While they were extremes in this respect, as selections from a segregating population they need not have resembled the parental Criollo and Forastero types in other respects. However, this does not render the trial valueless, as it will still enable selection of parents for production of seed of proven quality.

*KTC*10. *Amazonian Cacao Introductions*

In early 1960 a decision was made to introduce Amazonian cacao to the Territory. Two clones Na32 and Pa35 were introduced from Fiji to Canberra through the C.S.I.R.O. These clones were raised at Canberra, hand-crosses were carried out and the first seed was forwarded to Laloki in early 1963.

In addition hand-crosses within the Nanay, Parinari, Scavina and Iquitos groups and between these groups and I.C.S. numbers were made at the Imperial College of Tropical Agriculture, Trinidad, by Papua-New Guinea students at the College.

Seedlings from the first crosses made arrived at Keravat in November-December 1961. Approximately 180 seedlings of 8 crosses within the Parinari group were received. In April 1962 a second consignment was received which comprised seedlings of 4 Na x Na crosses and seedlings from open-pollinated pods from I.C.S. clones grown at River Estate, Trinidad, together with seedlings from 6 pods of West African Amelonado from Malaya. A third consignment arrived at Keravat in April 1963 and consisted of 450 seedlings of 15 Pa x Pa crosses, 3 Imc x Imc, 5 Na x Na and one Sca x Sca cross. The following list shows the parentage of all seedlings received at Keravat to the end of June 1963:

Pa 13 x 285	Pa 149 x 137	Pa 151 x 29
Pa 30 x 285	Pa 128 x 126	Pa 207 x 138
Pa 15 x 195	Pa 73 x 168	Pa 179 x 132
Pa 169 x 98	Pa 137 x 126	Imc 67 x 94
Pa 189 x 324	Pa 100 x 20	Imc 54 x 76
Pa 195 x 127	Pa 73 x 139	Imc 56 x 2
Pa 107 x 16	Pa 128 x 149	Na 935 x 874
Pa 15 x 127	Pa 218 x 200	Na 312 x 444
Na 31 x 32	Pa 162 x 137	Na 406 x 387
Na 31 x 34	Pa 15 x 276	Na 782 x 481
Na 33 x 32	Pa 61 x 139	Na 406 x 222
Na 33 x 34	Pa 71 x 26	Sca 8 x 24

The design of the gardens into which this material was planted depended on the shape of the blocks and the number of seedlings of each cross available. Where possible 3 x 3 or 4 x 4 plots were planted with a double row surround of a self-compatible Trinitario clone. The clones used were Keravat selections chosen for high yield and large beans. KA5.104, the best yielding clone in Clone Testing

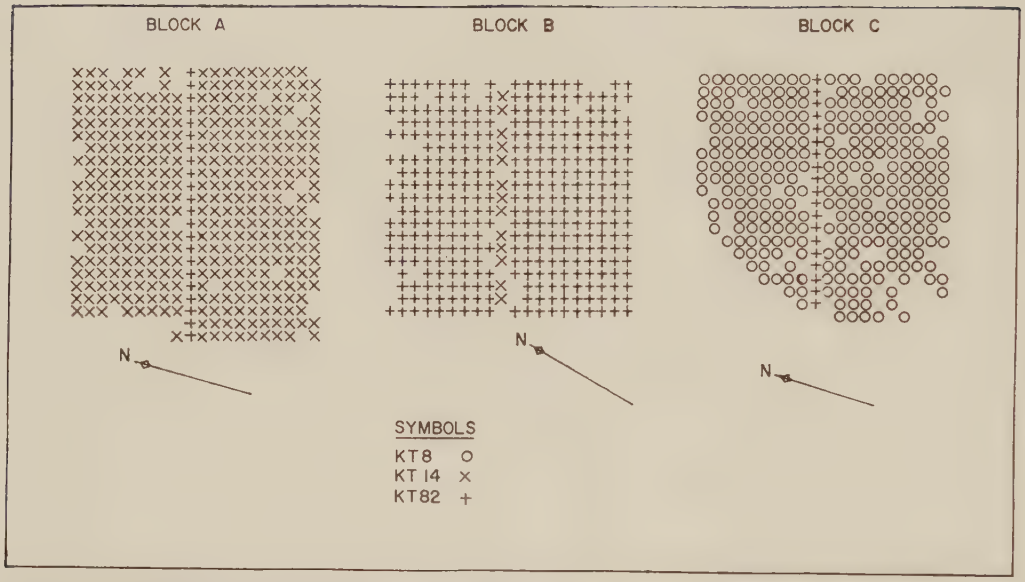

Figure 7: Plan showing layout of pollen dispersal trial blocks at the Lowlands Agricultural Experiment Station, Keravat.

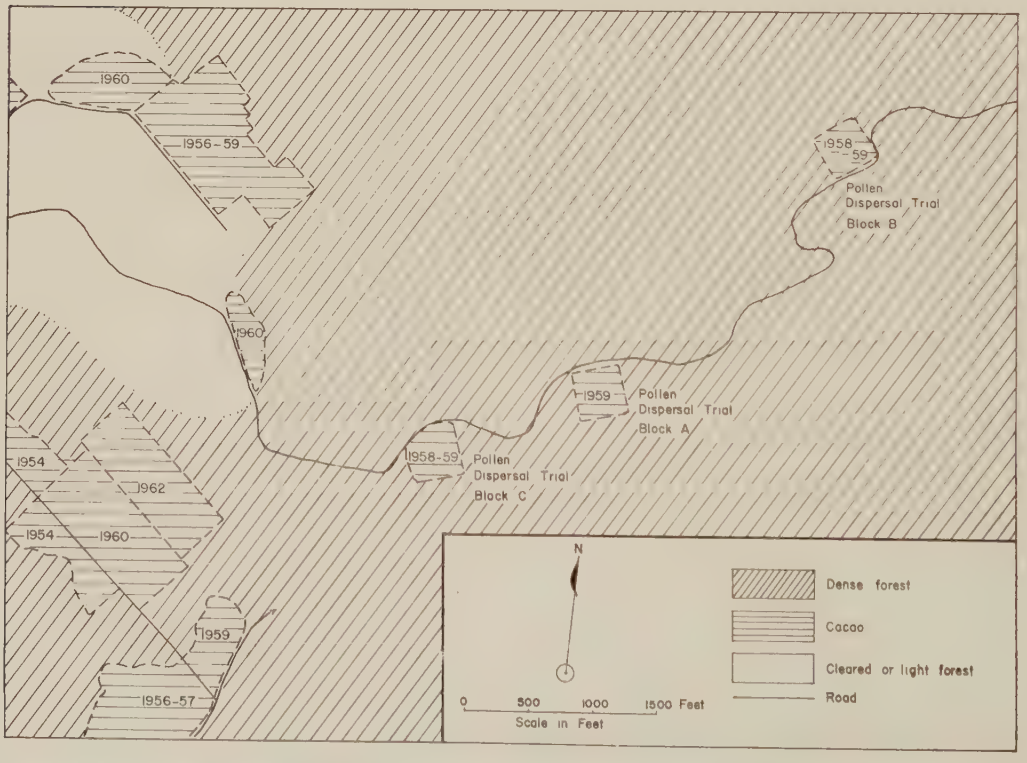

Figure 8: Map showing position of pollen dispersal trial blocks at Keravat in relation to other cacao plantings. Approximate dates of planting are shown on the cacao blocks.

Series I, and clonal seed and bulk seed were included in the blocks for comparison. The clonal seed used was collected from the best self-incompatible plots in the Clone Testing Series, while the bulk seed was collected from pods taken at random from a general station harvest.

The self-compatible surround will serve as a pollen source and guard. When the Amazonians produce sufficient numbers of flowers, hand-crosses will be made using the surround self-compatibles as male parents. The resultant seed will be tested and proven seed will be available from the gardens 3-4 years after the hand crossing. At that stage the proof will be slight, but probably adequate if based on vigour, yield and bean size.

KTC7. Pollen Dispersal Trials

The layout of the three plots in these trials is shown in Figure 7. Each plot contains a single " marker " line in the centre with a surround of another clone such that self and cross pollination can be detected by the colour of the beans produced. The three clones used are—

KT8—" white " self-incompatible (giving pure white beans when crossed with a self-compatible clone with white beans).

KT14—" white " self-compatible (giving pure white beans on selfing).

KT82—" purple " self-compatible (giving purple beans on selfing).

The expectation is that pollination of KT8 or KT14 pods by KT82, and the reciprocal crosses, will give an intermediate or violet bean colour. Hand pollinations before the trials were laid down indicated that this was correct, but some unexpected colours were found in trial C. Several hand pollinations of KT8 x KT82 were therefore made. In nine pods harvested, of a total of 302 beans, 292 were a definite violet as expected, one was a paler violet and one was white, while the remaining eight were imperfectly formed or empty beans. The one white bean in nine pods is more likely to have resulted from contamination during pollination than to indicate genetic variation.

Nevertheless, in examination of the hundreds of pods harvested, some pods were found where it was difficult to classify with confidence. In general, classification of beans on the " white " clones KT8 and KT14 is more reliable than on the " purple " clone KT82, as it is easier to detect violet amongst white than amongst purple. Also a few pods on KT82 contained beans all of which were quite a pale violet. This indicates that sometimes colour develpoment may be incomplete, since KT82 should never produce anything paler than the violet obtained in the cross with KT8 or KT14. Many pods on KT8 and a few on KT14 had beans much paler than expected from KT82 pollination, and often varying in colour within the pods. The observation of incomplete colour development on KT82 suggests that this may occasionally have been the cause. However, all the evidence strongly favours the conclusion reported earlier that most such pods resulted from extraneous pollination (i.e. pollen coming from cacao outside the pollen dispersal trials).

A number of " foreign " trees were found in the plots, and were removed as soon as detected. As they had mostly only just started to bear, the contamination introduced would have been only slight. Many of them were identified as KT14, planted by mistake in the KT8 or the KT82 surrounds. About 15 foreign trees were removed from each of trials B and C; one was found in trial A.

Considerable damage was caused by borers and dieback, resulting in losses of many trees in all blocks. These losses were more substantial than indicated in Figure 7, which shows the number of trees surviving in December 1962, since many surviving trees had been severely pruned and were no longer bearing. The most serious losses were in the KT14 marker row in Block B, where in June 1963, seven of the nineteen trees were missing and more than half of those surviving were severely damaged.

Sampling: Throughout recording, in trial C all pods were examined and recorded on an individual tree basis. In trials A and B, until October 1962 pods were bulked from each line and all examined and recorded. This gave a good measure of pollen dispersal at right angles to the marker row, but no measure of movements in other directions. From October, pods were examined on an individual tree basis, but to reduce the very considerable work involved only one pod from each tree was examined at each harvest in the surrounds of blocks A and B. All pods were examined on the marker rows.

Most of the colour determinations were made by cutting the pods longitudinally with a " guillotine " with two knife blades about an inch apart. This cut and showed the colour of a minimum of 10 beans per pod, usually at least 15. In many of the pods from Block C it was desired to count the beans, so the guillotine could not be used. For these, beans were extracted in the normal way and a sample of 10 was cut to determine colour.

Results: A summary of the classification of all pods harvested is presented in Table 39.

TABLE 39. KTC7 CACAO POLLEN DISPERSAL TRIALS

PODS HARVESTED AND EXAMINED 1961–62 AND 1962–63

	Number Harvested	Number Examined	Percentage Pods in Each Class			
			Selfed	Crossed	Mixed	Extraneous
TRIAL A—						
KT14 61–62	2,884	2,884	97.1	0.7	1.8	0.4
62–63	**9,427**	**4,789**	**94.8**	**1.8**	**3.4**	**0**
KT82 61–62	34	34	68	29	3	0
62–63	**539**	**539**	**50**	**20**	**30**	**0**
TRIAL B—						
KT82 61–62	3,986	3,986	99.6	0.1	0.3	0
62–63	**11,823**	**5,436**	**98.4**	**0.7**	**0.9**	**0**
KT14 61–62	15	15	20	53	27	0
62–63	**129**	**129**	**17**	**53**	**30**	**0**
TRIAL C—						
KT8 61–62	1,193	1,193	25*	57	10	8
62–63	**3,240**	**3,240**	**20***	**62**	**10**	**8**
KT82 61–62	649	649	56	30	14	0
62–63	**1,385**	**1,385**	**50**	**30**	**20**	**0**

* All pods with white beans only.

Trial A: Influence of pollen from the marker row extended throughout the block but decreased with increasing distance. During 1962-63, when both clones were producing substantially, the percentage of non-selfed pods was 6.6 per cent. in the three rows adjacent to the marker on either side, and 3.9 per cent in the three outside rows on either side. There were also variations with time in the proportion of crossed and mixed pods on both marker and surround. On both, there were more crossed pods than mixed in the period July to September 1962, but more mixed than crossed from October 1962 to June 1963.

Trial B: The poor growth and severe damage to the KT14 marker row in this block is evidenced in the small numbers of pods it produced. During the months April to June 1963, only four pods were produced from the marker, at a time when the other clones in the trials produced a peak crop. Pollen production must be very low, and it appears that this trial is unlikely to yield any further information.

During 1962-63 the proportion of non-selfed pods declined from 2.4 per cent. in the three rows adjacent to the marker on either side to 0.8 per cent in the three outside rows on either side. As in block A, in both marker and surround the relative proportions of mixed pods to crossed was lower up to September 1962, than from October 1962 to June 1963.

Trial C: The classification in Table 39 includes 20-25 per cent. of "selfed" pods. Since KT8 is self-incompatible (this was confirmed in 1962 by hand-pollinations on trees in Trial C) this requires some explanation. All pods containing only white beans have been included under the heading "selfed". In fact, some of these would have resulted from pollination by the KT14 contaminants found within the block, and many more probably from pollination from KT14 in Trial A (see figure 8). However, the much higher proportion of pods with white beans than of other pods classed as extraneous gives support to the theory that under conditions where pollination is limiting some selfed pods may survive on a normally self-incompatible clone.

It was noted also that many pods from KT8 had fewer beans than normal. To study this in detail, bean numbers were counted in all pods harvested between 12th December 1962 and 7th May 1963, a total of 1,879 pods. This showed a definitely skewed distribution of bean numbers, which ranged from 4 to 48, with a mode of 37 and a mean of 30 beans per pod. Bean numbers were especially low in pods with only white beans, and in these the distribution showed two modes, one at about 37 and another at about 13 beans per pod. Pods from KT8 in a cutting material nursery where it was surrounded by other clones showed far fewer low bean numbers, and it is probable that the low numbers in the pollen dispersal trial may be attributed to general deficiency of compatible pollen permitting imperfectly fertilized pods to mature.

As in the other trials, a decline in marker influence was evident with increasing distance. In 1962-63 the number of pods with all violet beans (crossed pods) decreased from 10.8 per bearing tree in the three rows adjacent to the marker on either side to 5.6 in the three outer rows on either side. There was also a change with time in the proportion of mixed pods on the marker row, being much lower prior to September 1962, than in later months. In the surround, the only notable change with time was a fall in the proportion of white bean pods towards the end of the year (at the time of peak harvests), and an increase in the proportion of " extraneous " pods.

Cacao Incompatibility Tests

Compatibility testing of Keravat's selected mother trees was in most cases carried out in the early 1950's. Subsequent work on hand pollinations has indicated that the technique then in use may have classed some trees as self-incompatible which were in fact self-compatible, although those classed as self-compatible are probably all correct.

Several " self-incompatible " clones have therefore been retested. In these tests it was considered that any flower shed within two days of pollination had not been effectively pollinated, and comparisons were based on the number of effective pollinations rather than on the total number of pollinations.

In clones where all self-pollinated flowers shed, flowers were also cross-pollinated with compatible pollen for comparison of successes. Results were finally assessed seven days after pollination, by which time growth of the ovary is well marked in the case of compatible pollinations. In incompatible pollinations the flowers rarely hold as long as seven days, and, if holding, show little or no growth of the ovary.

Up till May 1963, all flowers were covered before opening to prevent natural pollination. After May, comparisons were made with uncovered flowers, using as a control a similar number of flowers which were not hand pollinated. The number of these which held for more than 2 days was taken as an index of the extent of natural pollination. Results of each method are shown separately in Tables 40 and 41.

Results in Table 40 show clearly that clones tested were mostly self-incompatible, with the exception of K23.103 and KA5.103 which were clearly self-compatible, and K4 where almost all flowers shed within two days of pollination. K4 was tested further by using its pollen on flowers of a self-incompatible clone and a self-compatible clone. Results were: 51 pollinations, 17 effective, 0 growing on the self-incompatible clone; and 11 pollinations, 10 effective, 9 growing on the self-compatible clone. Thus K4 is definitely self-incompatible.

TABLE 40. SELF-COMPATIBILITY TESTS OF CACAO CLONES

COVERED FLOWERS

Clone	*Self Pollination*			*Compatible Cross Pollination*		
	Number Pollinated	*Number Effective*(1)	*Number Growing*(2)	*Number Pollinated*	*Number Effective*(1)	*Number Growing*(2)
KT8	27	24	0	28	20	17
K3	25	15	0	22	15	10
K4	41	0	..	16	2	1
K6	32	18	0	30	18	17
K16	54	24	0	21	10	6
K17	26	14	0	13	11	8
K20	58	27	0	15	12	11
K23	32	21	0	13	12	8
K28	23	16	0	11	9	9
K6.101	24	19	0	5	5	5
K19.101	17	13	0	8	5	4
K23.103	38	35	29	..	..	..
K25.102	24	19	0	4	3	3
K27.102	20	11	0	25	14	11
KA5.103	21	16	12	..	..	..
KA5.104	24	22	0	6	6	4

(1) Effective pollinations = flowers holding more than two days. (2) Flowers showing growth of the ovary after seven days.

In Table 41, results are clear cut for most of the clones. KA2.101 and KA5.101 were checked by self-pollination of covered flowers. On KA2.101, 14 pollinations gave 10 effective and 9 growing, confirming it as a self-compatible. On KA5.101, 11 pollinations gave 9 effective and 0 growing, showing it to be self-incompatible. Results also indicate natural pollination to have been of the order of 10 per cent.

TABLE 41. SELF-COMPATIBILITY TESTS OF CACAO CLONES

NON-COVERED FLOWERS

—	*K11*	*K25*	*K32*	*K24.102*	*K24.103*	*KA2.101*	*KA2.105*	*KA5.101*
Self-Pollination—								
Number pollinated	19	20	20	20	20	18	20	20
Number effective..	15	17	19	18	8	10	18	11
Number growing..	13	0	0	0	1	6	0	3
Compatible Cross Pollination—								
Number pollinated	20	20	20	20	20	21	20	20
Number effective..	19	18	17	13	17	13	19	13
Number growing..	17	17	16	6	7	11	13	12
Natural Pollination—								
Number marked ..	20	20	20	20	20	21	20	20
Number effective pollinations ..	3	3	3	1	0	3	1	3
Number growing..	1	0	0	0	..	1	0	0

CACAO AGRONOMY

KTC3. Shade x Spacing x Fertilizer Trial—Block 506

Interpretation of the results of this trial is difficult because of the large differences there have been between replicates of the same treatments. Coupled with the lack of randomization in the block, this variability means that any apparent treatment differences must be treated cautiously and only the most outstanding can be accepted with confidence.

A general summary of plot yields, converted to numbers of pods per acre, for the eight different treatments, is shown in Table 42. Details of fertilizer treatments are that urea was applied at 212 lb. per acre per annum on fertilized plots from November 1958 till September 1960. From December 1960 rates were 4 lb. urea per tree per annum, or 1,392 lb. per acre at 12 ft. spacing and 900 lb. per acre at 15 ft. spacing. All fertilizer applications were split into four dressings at three monthly intervals.

Spacing effects may be considered by comparison of unfertilized plots. In the shaded plots, total yield 1957 to 1963 was slightly higher at 15 ft. (70,399 pods) than 12 ft. (65,174), but the difference is too small to be significant. In the unshaded plots, yield was higher at 12 ft. (68,922) than at 15 ft. (62,521).

Considering shade effects on unfertilized plots, at 12 ft. spacing unshaded plots yielded slightly more than shaded, but at 15 ft. the unshaded plot yields were lower. This difference may be valid, as self-shading is much greater at 12 ft. than at 15 ft. spacing. However, yields of the 12 ft. unshaded plots have shown very great fluctuation from year to year and it appears that shade has a stabilizing influence on yield.

The response to nitrogen appears to be little or none on shaded plots, moderate on unshaded plots. Over the period 1959-63 both spacings showed a total increase, in the absence of shade, of about 16,000 pods per acre, representing a gain over the controls of about 30 per cent. However, even these differences are not significant when analysed statistically, because of variability between replicates.

TABLE 42. KTC3. CACAO SHADE x SPACING x FERTILIZER TRIAL

YIELDS IN PODS PER ACRE

—	*12 ft. triangle*				*15 ft. triangle*			
	Shade		*No Shade*		*Shade*		*No Shade*	
	Control	*+N*	*Control*	*+N*	*Control*	*+N*	*Control*	*+N*
1957–1959 Pretreatment Average	12,268	**13,634**	10,079	**10,947**	12,676	**10,737**	10,576	**10,971**
1959–60	15,583	**16,333**	21,015	**23,384**	17,119	**14,455**	13,094	**17,457**
1960–61	12,188	**13,292**	12,490	**15,061**	12,630	**11,041**	9,476	**12,860**
1961–62	11,470	**13,356**	8,648	**15,565**	12,844	**12,272**	11,011	**15,099**
1962–63	13,665	**15,046**	16,690	**21,957**	15,130	**13,228**	18,364	**22,345**

Several more trees died during the two years, and distribution of deaths within the treatment is shown in Table 43.

TABLE 43. KTC3. CACAO SHADE x SPACING x FERTILIZER TRIAL

TOTAL DEATHS OF TREES TO JUNE 1963 (PER CENT.)

	12 ft. Triangle		*15 ft. Triangle*	
	Control	*+N*	*Control*	*+N*
Shade ..	7.1	5.8	10.0	17.1
No shade ..	8.3	12.5	23.8	22.9

Girths of all trees were measured in February 1963, and were fairly consistently higher at 15 ft. than at 12 ft. and in unshaded than in shaded plots. Average girths were as follows—

12 ft. shaded = 17.8 in.
12 ft. unshaded = 20.5 in.
15 ft. shaded = 20.6 in.
15 ft. unshaded = 22.8 in.

KTC2. Cacao Shade Trial, Block 405

The trend of increased yield with decreased shade has continued. Table 44 shows post-treatment yields which have been adjusted by covariance analysis on the average yields 1956 to 1958 (i.e. adjusted on the basis of equal yield in the pretreatment period).

TABLE 44. KTC2. CACAO SHADE TRIAL—BLOCK 405

ADJUSTED YIELDS, CONVERTED TO PODS PER ACRE

	Nil Shade	*¼ Normal*	*½ Normal*	*Normal*	*Least Sig. Diff.*	
					5 per cent.	*1 per cent.*
1959–60	19,021	17,338	14,643	11,475	3,240	4,713
1960–61	15,194	12,941	10,714	8,794	2,765	4,022
1961–62	14,163	12,838	10,368	9,139	2,930	4,262
1962–63	18,100	15,400	12,400	10,800	..	..

In 1963, plots of the shade trial were split for a fertilizer trial. The shade plots contain 130 trees but up till 30th June 1963 results were based on yields of 35 trees in the centre to allow wide guarding between shade levels. Study of yields at different levels had shown that there was probably some influence from shade in adjacent plots up to a distance of 45 feet, and the 35 tree plot allowed approximately 45 feet guarding. However, beyond 30 ft. any effect was slight, and to allow more trees for the fertilizer comparison guarding was reduced to about 30 ft. giving an inner plot of 63 trees. This was split into two sub-plots of 28 trees each with a line of 7 trees to form a common internal guard. Fertilizer treatments were applied to these sub-plots of 28 trees at two levels—nil control and one positive level. The first application made on 26th June 1963 consisted of one and a half pounds per tree of a 20:20:14 NPK mixture. Complete fertilizer was used initially because fairly heavy pruning for dieback had recently been carried out. Future dressings, to be applied at three monthly intervals, will probably be of urea alone. The aim is to apply what is considered likely to be economic in general practice and to study the interaction with levels of shade.

Change in the plots involved a different set of trees, and Table 45 shows a summary of pre-fertilizing yields for the sub-treatments. Fertilizer treatments were assigned at random within the plots with some adjustment to give approximately equal pre-treatment totals for F_0 and F_1. These yields will be used for covariance adjustment of post-treatment yields.

The girths of all trees included in the sub-plots were also measured, so that some measure can ultimately be made of the effect of fertilizer on tree vigour. Leaf samples were taken for chemical analysis prior to fertilizing, and sampling will be continued.

TABLE 45. KTC2. CACAO SHADE FERTILIZER TRIAL BLOCK 405

PRE-FERTILIZER YIELDS OF FERTILIZER PLOTS

(Total numbers of pods from 4 replicates of 28 tree plots.)

	Nil Shade		*¼ Shade*		*½ Shade*		*Full Shade*		*Total*	
	F_0	F_1	F_0	F_1	F_0	F_1	F_0	F_1	F_0	F_1
Pre-Shade Treatment Average 1956–57 + 1957–58 ..	4,136	**4,176**	5,329	**4,413**	3,993	**4,029**	4,444	**4,408**	17,902	**17,026**
Intermediate Shade 1958–59 ..	4,945	**5,134**	5,989	**5,822**	4,579	**5,176**	4,369	**4,198**	19,882	**20,330**
Post-Shade Treatments:										
1959–60	8,887	**9,433**	9,753	**9,393**	6,829	**7,061**	6,019	**5,871**	31,488	**31,758**
1960–61	7,356	**7,824**	6,936	**6,701**	5,048	**5,359**	4,573	**4,319**	23,913	**4,203**
1961–62	7,806	**7,648**	6,708	**6,682**	5,077	**5,179**	4,528	**4,411**	24,119	**23,920**
1962–63	10,267	**8,896**	8,704	**8,098**	6,164	**6,379**	5,081	**5,904**	30,216	**29,277**

Note: F_0 = no fertilizer; F_1 = fertilizer.

*KTC*11. *Cacao Shade x Spacing x Fertilizer Trial Blocks* 309, 408, 409

This is an extension of the earlier observational trial in block 506 to give more accurate results (through adequate replication and guarding) and to extend the comparison to three spacings and three levels of fertilizing. In particular, information is desired on interactions which, in block 506, are confounded with replications.

Shade: All trees are to be raised under normal shade, but as they approach maturity shade will be removed from some plots. The level of shade in the shaded plots will be maintained at what seems most satisfactory in the light of other trials. Shade removal for the no-shade treatment will be gradual over a period of about twelve months, probably commencing when the trees are three to four years old. Prior to this, routine shade thinning will be applied equally to both treatments.

Spacing: The three spacings to be tested are nominally 8 ft., 12 ft. and 16 ft. triangle. In fitting the trial to the land available these spacings were modified slightly to the equivalent of 7.81 ft., 11.27 ft. and 14.76 ft. equilateral triangle, with variations from the equilateral in different replicates. The spacings were chosen on the basis of current indications that standard culture under shade without fertilizer gives optimum yields at 12 ft. spacing.

Fertilizer: Provision is made for a zero control and two positive levels of fertilizing. The type of fertilizer and frequency of application will be decided in the light of experience up to the time when fertilizing is commenced. Originally it was intended to fertilize only at maturity, with nitrogenous fertilizer only. However, it has subsequently been decided to include a comparison of early fertilizing with a complete fertilizer mixture.

Design: Because of extensive guarding required between shade treatments, spacing and fertilizing treatments are to be applied as subplots within the shade treatment plots.

There are six plots with shade, eight plots without shade. The higher number without shade is because of an expectation of greater fertilizer response without shade. Within each plot are three sub-plots of spacings. Within each of these there are three sub-sub-plots for levels of fertilizer.

Guarding: The shade plots are guarded around the perimeter to a depth of 30 ft. The no-shade plots are guarded to this depth if contiguous to a shade plot, otherwise singly guarded at the boundary. There is an internal double guarding for spacing and a single guard for fertilizer.

The whole trial covers approximately 15 acres and there are 938 trees in each of the three fertilizer treatments.

Site: The trial is located in an area which had been planted with food gardens during the war and thereafter left unused. In 1958 it was cleared and planted with *Leucaena* shade. The area is flat and for the most part uniform, though attention has had to be given to drainage in a small section of block 408 and shade growth has been rather poor over a fairly large section of block 409.

Planting: Cacao was planted at stake during July and August 1962. Seed was taken from self-incompatible clones in the clone-testing trials. Germination and early growth was mostly excellent and only a very low proportion of replacements had to be made. Early growth was somewhat retarded in the part of 409 where shade had not grown so well, but with improved weather about May 1963 growth picked up.

*KTC*4. *Seedling Spacing Trials*

Triangular Spacings: Earlier shade thinning had left a ratio of one *Leucaena* to one cacao tree in both the 12 ft. and 15 ft. plots, with a higher ratio at the wider spacings. This meant that shading was heavier at 12 ft. than 15 ft., whereas if anything, the reverse would be preferable. In May 1962, shade levels were reduced in the 12 ft. plots to approximately 225 trees per acre to correspond with the 15 ft. plots. At the same time, levels on the 17 ft. 2 in. plots were reduced to about 340 per acre, while the 20 ft. plots were left at about 375 per acre and the 24 ft. plots at 435 per acre. The higher levels of *Leucaena* shade at wider spacings allow for the much lower levels of self-shading between cacao trees.

Yields for 1961 and 1962 and girth measurements are shown in Table 46.

TABLE 46. KTC4. CACAO SEEDLING SPACING TRIALS—TRIANGULAR SPACINGS

YIELDS (NUMBERS OF PODS) AND GIRTHS (INCHES)

	Spacing				
	12 ft.	*15 ft.*	*17 ft. 2-in.*	*20 ft.*	*24 ft.*
Trees per acre ..	349	224	171	126	87
Yield per acre—					
1961 ..	7,658	6,994	6,329	4,852	5,258
1962 ..	**13,210**	**12,535**	**11,505**	**7,527**	**8,848**
Yield per tree—					
1961 ..	21.9	31.3	37.1	38.6	60.2
1962 ..	**37.8**	**56.1**	**67.4**	**59.9**	**101.3**
Average Girth—					
September 1960	10.4	10.6	10.6	10.7	10.9
November 1961	12.6	13.4	13.6	13.3	13.9
October **1962** ..	**13.8**	**14.5**	**15.1**	**14.7**	**15.3**

Plate 7. Cacao seedlings planted at 24 ft. x 6 ft. hedge spacing. Note weed growth between the rows where the canopy is not complete, and the tendency for branches to droop. (*Photo: A. E. Charles*)

Yield continued to be higher at the closer spacings, although the relative advantage was reduced. The apparent superiority of 24 ft. over 20 ft. is undoubtedly fortuitous, resulting from the small numbers of trees per plot, insufficient to eliminate genetic differences (tree numbers are 11 at 24 ft., 14 at 20 ft., as against 60 at 12 ft.).

Tendency of the wider spaced trees to droop to the ground increased as they aged. The canopy was complete in the 15 ft. plots by March 1962 and in the 17 ft. 2 in. plots by June 1963. At the latter date it was complete in parts of the 20 ft. plots also, but grass growth remained heavy at 24 ft. spacing.

Hedge Spacings: Routine shade thinning was carried out in March 1962. Yields in pods per acre are shown in Table 47.

TABLE 47. KTC4. CACAO SEEDLING SPACING TRIALS—HEDGE SPACINGS

YIELDS (NUMBERS OF PODS) AND GIRTHS (INCHES)

		Spacing	
		18 ft. x 8 ft.	*24 ft. x 6 ft.*
Yield per acre:	1961 ..	2,831	2,529
	1962 ..	**6,275**	**6,235**
Yield per tree:	1961 ..	9.3	8.3
	1962 ..	**21.0**	**20.6**
Average Girth:	1960 ..	7.45	7.64
	1962 ..	**11.43**	**11.25**

Yield variation between plots was extremely high; in 1961 it ranged from 4 to 19 pods per tree. An attempt was made to correct this by using the average girth of trees measured in 1960 as a covariate for adjustment of plot yields up to 1962. This girth should be a fair index of vigour of the trees at a period before treatment effects would be operative, and thus an index of growing conditions in the plots. Covariance analysis showed a correlation coefficient of 0.988 (significant at 5 per cent.), between yield and previous girth, and the difference between spacings significant at 5 per cent. Adjusted yields became 9,810 pods per acre for 18 ft. x 8 ft. and 8,140 pods per acre for 24 ft. x 6 ft. The data are rather meagre to accept this result as proven, but it would conform to expectations. The 18 ft. x 8 ft. plots had formed a complete canopy by 1963, while the 24 ft. x 6 ft. plots had not, suggesting a fuller utilization of available space by the less extreme hedge spacing. The change in relative girths at the two spacings is also noteworthy.

Closer spacings—Block 1010: A new trial was commenced in 1962 to compare performance of cocoa planted at closer spacings and to include a reliable comparison between hedge spacings and triangular spacings.

The design was a randomized block with 4 replicates of 6 treatments, as follows—

(i) 8 ft. triangle (786 trees/acre)
(ii) 10 ft. triangle (502 trees/acre) single tier
(iii) 10 ft. triangle (502 trees/acre) two or more tiers
(iv) 12 ft. triangle (348 trees/acre)
(v) Hedge spacing, with rows as for 15 ft. triangle, but spacing 7 ft. 6 ins. within the rows (i.e. twice the number of trees = 447 trees/acre)
(vi) Hedge spacing, 18 ft. x 8 ft. (303 trees/acre).

Concerning the two 10 ft. triangle spacings, one of these is to be allowed to throw chupons and form more than one tier of growth, as is common practice in West Africa. The remainder of the treatments will be kept at a single tier as is normal practice in this country.

Plots are parallelogram shaped, with a single outer guard line of trees. Sizes of plots are—

8 ft. triangle	..	72 plot trees, total	110
10 ft. triangle	..	42 plot trees, total	72
12 ft. triangle	..	30 plot trees, total	56
15 ft. hedge	..	40 plot trees, total	72
18 ft. x 8 ft. hedge	..	24 plot trees, total	50

The block chosen was cleared in 1960 and planted with *Leucaena* shade. Cacao was planted at stake in March 1962, seed being taken from the best yielding self-incompatible clones in the clone testing trial.

Seedlings mostly came away well with only a small number of replacements necessary. Some insect damage was suffered, but by June 1963 most of the seedlings had ramified. Growth was not uniform over the whole area, and in February 1963, heights of all seedlings were recorded for possible use as a covariate to correct subsequent yields. Average heights for the plots ranged from 26.6 inches to 40.7 inches.

KTC6. Spacing x Pruning Trial—Clonal Material

Yields at the different spacings are shown in Table 48.

Variation between replicates was extreme, so that no conclusion can be drawn regarding optimum spacing. These results may indicate that, within the range tested, spacing has little influence on yield.

Pods from pruned plots totalled 4,636 in 1961-62 and 4,428 in 1962-63, and in unpruned plots 5,503 and 4,826 respectively. The apparent fertility gradient mentioned in the 1960-61 Annual Report is no longer so prominent and in 1962-63, the unpruned sub-plots outyielded the pruned sub-plots in every plot. It is therefore probable that pruning does cause some real reduction in yield.

A heavy pruning treatment was carried out in July 1961, with the object of removing all low growth plus younger branches which would eventually droop down. In some cases this involved the removal of most of the old wood of the tree, leaving one or two upright fans as the final structure. Another light pruning was made in April 1962 to remove young fans and chupons coming away from the bases of the trees.

The effect of the 1961 pruning was much greater ease of access to the trees, relative to the unpruned plots. This effect was still noticeable at June 1963, when the trees were six years of age. By this age, some self-pruning, through shading out of lower limbs, had occurred in the unpruned plots, but there were still a number of low-growing branches which, although slight and whippy, would impede the passage of a worker carrying spraying equipment or a harvester carrying pods. Foliage of the unpruned hedges was slightly higher off the ground than that in the unpruned triangle spacings.

TABLE 48. KTC6. CACAO SPACING x PRUNING TRIAL—CLONAL MATERIAL

POD YIELDS 1961–63

Spacing	*Yields in Pods per Acre*				*Mean Annual Yield 1961–63*	
	1961–62		*1962–63*			
	Rep. 1	*Rep. 2*	*Rep. 1*	*Rep. 2*	*Pods per Acre*	*Pods per Tree*
9 ft. triangle	12,065	11,059	8,891	12,813	11,207	18.0
11 ft. 6 in. triangle ..	9,668	14,960	8,562	12,409	11,400	30.0
14 ft. triangle	9,015	15,391	10,366	14,121	12,223	47.6
18 ft. x 6 ft. hedge ..	11,745	16,143	9,886	13,513	12,822	31.9
18 ft. x 4 ft. hedge ..	11,999	14,321	11,495	13,503	12,829	21.1

KTC9. Nitrogen-Phosphorus Trial in Interplanted Cacao-Coconuts

Yield results in this trial had been surprising in that very little response to nitrogen was evident despite strong evidence of response to fertilizing on similar cacao elsewhere on the same and other plantations. Because of the failure to differentiate between the three levels of nitrogen applied in 1960, it was decided to revise the treatments to include a no-fertilizer control. To retain the maximum contrast between treatments, ½ lb. and 2 lb. urea per tree every 6 months was retained and the 1 lb. per tree rate was reduced to zero. The rate of ½ lb. superphosphate per tree was retained. Fertilizer applications were made in August 1961, April and September 1962 and January 1963.

In January 1962 lightning struck coconuts on the boundary between some of the plots. Ultimately several palms died, but only 4 of these were plot palms. In assessing the effects of fertilizer on coconut yields, nut counts for these four trees have been removed from pretreatment yields for covariance adjustment.

Nut counts were made on the coconuts in March 1962 and February 1963. Results are summarized in Table 49. There was an indication of a possible slight response in 1963, but it was not statistically significant.

TABLE 49. KTC9. FERTILIZER TRIAL ON INTERLPANTED CACAO-COCONUTS

AVERAGE NUMBERS OF NUTS PER PALM

——	N_3	N_6*	N_{12}	P_0	P_1
1962 ..	38	38	37	37	38
1963 ..	39	39	42	39	41

* Now N_0.

Cacao yields in 1961 were higher than in 1960, but again showed little response to fertilizer. However, in 1962 there was a greater response, which proved significant at 5 per cent. in analysis of covariance. In the first half of 1963 the response appeared greater again, but the figures have not been analysed.

At some harvests in 1962 and all harvests in 1963 weights as well as number of pods were recorded. The records indicated a possible reduction in pod size with fertilizer, but this was not very consistent and may not prove significant. In general it was found that between different harvests pod numbers and size were inversely related. Table 50 shows both actual pod numbers and numbers adjusted for pretreatment yield for 1961 and 1962 and pod numbers and weights for 1963. Details of chemical investigation associated with this work may be found under *Agricultural Chemistry*.

KTC17. Shade-Fertilizer Observation Plots

A rather puzzling feature of fertilizer trials with cacao in the Gazelle Peninsula has been a lack of marked response, despite the fact that yields are far below the levels of 3,000 lb. and more of dry cocoa per acre produced in some overseas trials with fertilized unshaded cacao. A small observation trial was therefore commenced in 1963 to see whether higher yields could be obtained by using a complete fertilizer mixture at a high level, applied from the time shade removal was commenced.

The trial was superimposed on the hand-pollinated seedling progenies in blocks 106 and 107, each of which was split into two sub-blocks numbered consecutively 106A, 106B, 107B, 107A. Block 106 was planted at 15 ft. triangular spacing between December 1952, and May 1954, and block 107 was planted at the same spacing between 1954 and 1957. Sub-blocks 106A and 106B each contained 297 trees and 107A and 107B each contained 384 trees.

TABLE 50. KTC9. FERTILIZER TRIAL ON INTERPLANTED CACAO-COCONUTS

PODS HARVESTED JANUARY 1961 TO JUNE 1963 (PLOT AVERAGES)

——	*January–December 1961*		*January–December 1962*		*January–June 1963*	
	Pod Nos. (Actual)	*Pod Nos. (Adjusted)*	*Pod Nos. (Actual)*	*Pod Nos. (Adjusted)*	*Pod Nos. (Actual)*	*Pod Weights (lb.)*
N_0 (formerly N_6)	3,747 (100)	3,688 (100)	4,000 (100)	3,955 (100)	2,139 (100)	1,788 (100)
N_3	3,898 (104)	3,816 (103)	4,788 (120)	4,646 (117)	2,703 (126)	2,313 (129)
N_{12}	4,035 (108)	4,176 (113)	5,093 (127)	5,278 (133)*	3,143 (147)	2,575 (144)
P_0	3,990 (100)	3,967 (100)	4,393 (100)	4,372 (100)	2,766 (100)	2,365 (100)
P_1	3,797 (95)	3,820 (96)	3,935 (90)	3,956 (90)	2,558 (92)	2,086 (88)

* Significant 5 per cent.

The A sub-blocks are to be controls, shaded and unfertilized, while B sub-blocks are to be unshaded and fertilized. Before commencement of the trial, shade throughout was brought to a standard level of one *Leucaena* shade tree to one cacao tree. Thereafter *Leucaena* in the B sub-blocks was to be thinned by removal of one fifth of the shade trees every three months.

Shade removal and fertilizing was commenced in February 1963. Fertilizer application is made every three months. The fertilizer mixture contains N, P, K, Ca, Mg and minor elements, the composition of the mixture being based on nutrient removal by a crop of one ton of dry beans per acre and the characteristics of the local pumice soil.

Cacao Planting Technique

The late Mr. W. Smith, of Cadbury-Fry-Pascall in Rabaul, brought to our attention a planting technique for cacao which he had seen practised in West Africa and had tried with success in Rabaul. The method was to plant seed in sand or loose soil in shallow boxes, and transplant seedlings to the field as soon as they have two well formed leaves—about three weeks after planting. Suggested advantages of the method were—

(1) compared with planting at stake,

  (a) seedlings at this stage are not harmed by snails so baiting is unnecessary.

  (b) economy of seed, since some selection can be carried out without the need to discard at least two thirds of seedlings as in planting three seeds per point.

(2) compared with raising in a nursery

  (a) seedlings need be spaced only about an inch apart in boxes. This results in considerable economy in nursery space, materials, and transport to the field.

  (b) the tap root is not bent at planting, as very commonly occurs when older seedlings are transplanted.

Tests of the technique were commenced in January 1962. Early indications were that transplanting at this stage was usually quite successful, with very little setback provided conditions were good or the seedlings were watered after transplanting. The tests confirmed that, at least under Keravat conditions, the seedlings were free from snail damage. In a test where 20 seedlings were transplanted side by side with 30 seed planted at stake with no snail protection, 19 transplanted seedlings survived and grew well and only 12 of those from seed survived and some of these were snail damaged. This test brought to light the fact that the susceptible stage is when the stem (hypocotyl) of the seedling is emerging and the cotyledons are still in the soil. However, it is not known whether a heavier snail population may attack seedlings after leaf formation occurs; snails certainly will attack older seedlings with hardened stems.

The tests did not confirm development of straight roots. Almost all were bent just below the surface of the soil, obviously at the point the roots had reached at the time of transplanting. Comparison with seedlings transplanted from pots showed that all their roots were bent too, but at a greater depth (6-9 inches below the surface).

In a further test, 90 seeds were sown at stake in a field plot under good *Leucaena* shade, and at the same time about 400 seeds were sown in sawdust in boxes. Thirty days later, when most of the seedlings in sawdust had four leaves, 350 of them were transplanted into pots adjacent to the seedlings planted at stake. Germination and growth of the seedlings planted at stake was generally somewhat inferior (only 68 germinations) to those raised in sawdust. In transplanting, the thin lower end of the taproot was nipped off about 50 seedlings before planting.

Soil was moist at the time of transplanting, and 84 points of rain fell about 30 hours later. Transplanting was very successful and only one seedling died in the first few weeks.

Two months after transplanting, the numbers of leaves on all seedlings were counted. These averaged 7.1 for planting at stake, 7.4 for transplanting with root nipped off, and 7.6 for transplanting without cutting the root.

After eight months, most of the seedlings were pulled out and the roots examined for straightness. Height above soil level and fresh weights were recorded. Results are summarized in Table 51. These show that the transplanting technique gave bad root formation, but this could be corrected by removing the tip at the time of transplanting. With good transplanting conditions, growth was as good as growth of seedlings planted at stake, and probably better.

Despite its success in this case, the technique has limitations which could be serious. Transplanting under dry conditions would undoubtedly be less successful, particularly with less shade, unless the seedlings were watered. As compared with raising

TABLE 51. CACAO PLANTING TECHNIQUE

SEEDLING GROWTH AFTER EIGHT MONTHS

——	Root Condition						Average Weight of Whole Seedling	Average Height above Soil
	Straight		Slightly Twisted		Badly Twisted			
	No.	Per cent.	No.	Per cent.	No.	Per cent.		
							gm.	in.
Planted at stake	36	*80*	7	*16*	2	*4*	30.4	17.2
Transplanted: root uncut ..	13	*5*	84	*34*	147	*60*	49.3	21.4
Transplanted: root tip cut ..	24	*62*	14	*36*	1	*2*	43.6	19.7

seedlings in bamboo pots or plastic bags, this method would be less flexible as seedlings could probably not be kept for more than a week or at most two weeks waiting for suitable weather conditions. Compared with planting at stake, the method does not give the same scope for selection as the sowing of three seeds at a point, since there is little differential growth up to the stage of transplanting from sawdust. Nevertheless, it does have three probable advantages—

(1) no need for snail protection.

(2) cheaper than transplanting from bags or pots.

(3) less bending of the tap root at transplanting than with transplanting of older seedlings.

COCOA FERMENTATION AND DRYING

Shallow and Deep Fermentation

Extensive work was carried out in earlier years to find a method of fermentation which would eliminate " dead ferments "—that is, ferments where the temperature failed to rise sufficiently, resulting in finished beans with poor chocolate flavour and frequently undesirable side-flavours. Results of this work were described by L. A. Bridgland (1959, *Papua and New Guinea agric. J.* **12** (2,3): 49-115), who recommended three modified fermentation methods (A, B and C) as giving more reliable results than the " old technique ".

Comparisons at Keravat over a period of two years, as noted in the 1960-61 Annual Report, failed to show any advantage of method C over the more standard seven day ferment, *turned every day,* with no resting period. This was probably due, not to any lack of reliability in method C, but rather to obtaining regular reliable results from the old technique. It appears that the problem of " dead ferments " may be restricted to new plantations in their early years of production, and method C may still prove useful for them.

During the last two years, the major work on fermentation was the long-term testing of method A, which involves an initial fermentation period in shallow boxes followed by final fermentation in deep boxes. Comparisons were made between complete shallow fermentation, combined shallow-deep fermentation, and normal deep fermentation.

Shallow Fermentation: Beans were fermented in long narrow boxes at depths varying from 10-16 in. and turned every day, originally for 6½ days, later for shorter periods.

Shallow-Deep Fermentation: Beans were fermented for the first 2½ days at a depth of 18 in. in two separate 5 ft. x 4 ft. sweat boxes and then on the morning of the fourth day of fermentation, combined into one deep ferment of 36 inches and fermented for a further four days. Turning took place every day at 7-8 a.m.

Deep Fermentation: Standard 36 in. ferments with turning every day and a fermentation time of 6½ days.

Results from the trials, including flavour assessments on the beans produced, indicated that—

(a) Shallow fermentation must be regarded for the present as a very unsatisfactory technique unless further work can demonstrate a way of applying the system more successfully.

(b) Shallow-deep fermentation definitely showed no advantage over normal deep fermentation and appeared to give a slightly inferior product with regard to chocolate flavour, degree of fermentation, foul, foreign and foetid flavours and bitter and astringent flavours.

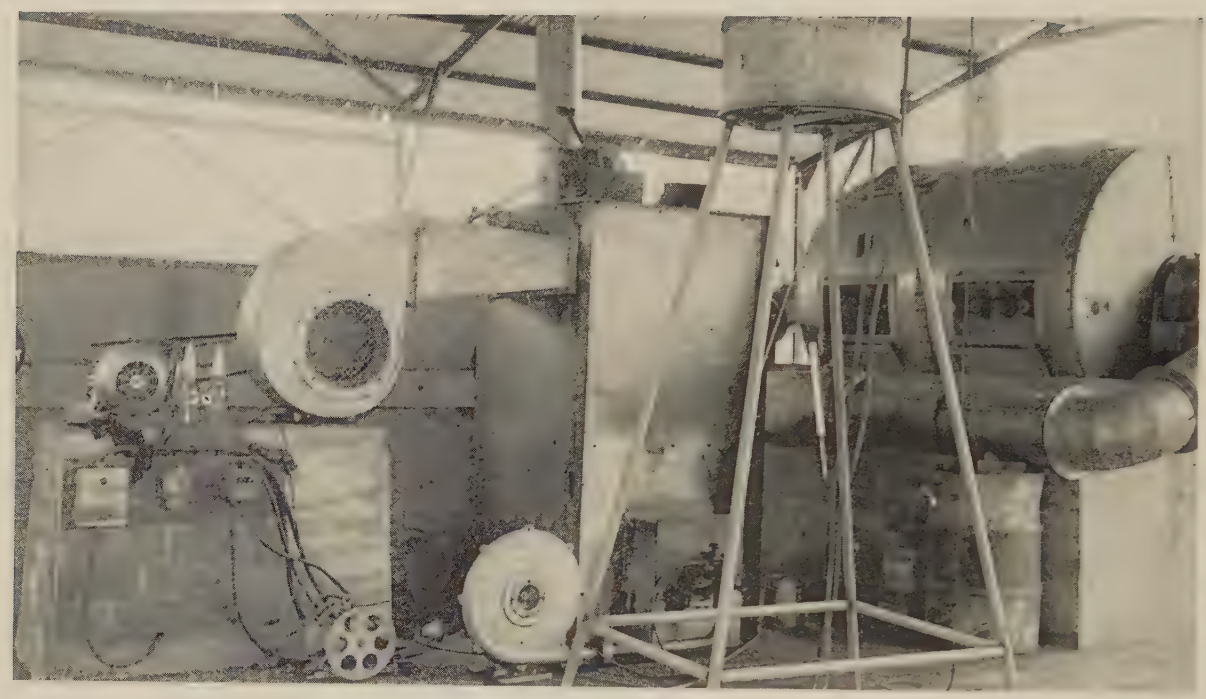

Plate 8. The Bentall Rotary Cocoa Dryer installed at Keravat for testing. (*Photo: L. Smee*)

Plate 9. The Lister Moisture Extraction Unit installed at Keravat for tests in drying cocoa on an 18 ft. x 12 ft. platform. (*Photo: L. Smee*)

Cocoa Drying Trials

Bentall Rotary Cocoa Dryer: A new hot air rotary cocoa dryer manufactured by E. H. Bentall & Co. Ltd. was installed for testing at the request of the manufacturers. The unit consists essentially of two out of four sections from the Company's 16 ft. x 6 ft. coffee dryer joined together to make an 8 ft. by 6 ft. cocoa dryer. Installation, which proved to be a major task, was completed in the early part of September 1961. From then until November 1962, a series of eighteen drying trials was carried out.

During installation of the unit it was found that the heat exchange system was too heavy and cumbersome for easy handling on a plantation and that the foundation work required to support the drum was elaborate and too extensive. It was also felt that design could have been improved both spacially and technically.

Initial trials were carried out with baffles fitted in each of the four drum compartments. These confirmed the deleterious effect of baffles towards the end of drying, when beans become worn or shattered. Further trials showed that, although the unit could not be used as a complete rotary dryer, it could be used as a final dryer after one day of sun drying provided that it was fully loaded and drum speed was reduced. However, the most satisfactory performance was obtained when the dryer was used for beans which had received an initial two days of sun drying on a platform dryer. Under these circumstances it proved capable of handling a load equivalent to approximately 2½ tons of dry beans and drying this load for a cost of 25.30 gallons of fuel per ton.

A comprehensive report " Cocoa Drying with a Bentall Rotary Dryer ", has been prepared for publication.

Lister Moisture Extraction Unit: A series of ten drying trials was carried out between January and June 1963, using a Lister Moisture Extraction Unit coupled to an 18 ft. x 12 ft. platform dryer. Results indicate that the unit has the capacity to dry safely 14,500 lb. of wet beans at a depth of 15 in. on the 18 ft. x 12 ft. floor to give three tons of good quality dry cocoa beans. This load can be handled by continuous drying for four full days at a cost of approximately 60 gallons of fuel and 5 pints of oil per ton of dry beans.

A comprehensive report on the trials has been prepared for publication. This contains full details of the relationship between water gauge pressure and temperature rise above ambient for the machine and also discussion on load capacity, drying rates and flavour assessments for the dry cocoa produced.

Direct Fired Drying: A direct fired drying trial was carried out in September, 1961, with copra drying equipment installed at Gire Gire plantation which had been made available for experimental work by the owner. The dryer had a circulation system which moved 8,000 c.f.m. at a 2 in. water gauge. Air passed over a cylindrical combustion chamber fitted with a domed and perforated top through which combustion gases pass to mix with the main airflow. A centrifugal fan pushed heated air under the 12 ft. x 7 ft. drying floor and a recirculation system returned approximately 50 per cent. of the air to the fan.

The bed was loaded to a depth of 8 in. with wet fermented beans processed under an uninterrupted seven day fermentation system, and the burner was set to give an air temperature of 140° F. Drying was quite rapid and beans were surface dry in approximately four hours. To reduce overall drying rate the machine was closed down for 10 hours and drying recommenced the following day with the burner operating for a further 8 hours. On the second and third days the burner was closed down periodically during drying so that air temperature could be maintained at about 130° F. Total drying time was 72 hours during which the machine operated for 20 hours and the burner for 14 hours.

At the conclusion of the trial, sun-dried bean samples and " direct-fired " bean samples were forwarded to three leading Australian chocolate manufacturers for their assessment and comments. As the manufacturers neither commented unfavourably on the direct-fired samples nor reported any foreign flavours, even despite the dryer being normally used as a copra dryer, the results encourage further work on the use of direct-fired drying for cocoa beans.

Tests on samples from another plantation which has installed direct-fired drying equipment were made in 1962-63, and did not reveal any harmful flavours from the combustion gases. Arrangements have been made to install a prototype direct-fired dryer for testing at Keravat, and tests will commence in July 1963.

VEGETATIVE PROPAGATION

Nursery work suffered some set-back in 1961-62 when the Horticulturist-Experimentalist resigned, leaving the position vacant for four months. This, combined with inadequacy of the old nursery, left a backlog of some 90,000 clonal cuttings on order at June 1962. With continuous staffing during the following year together with completion of the new nursery building and a simpler propagation technique, the position had improved by June 1963, although the backlog of orders was by no means eliminated. Improved methods permitted a substantial reduction in the price of cuttings sold.

New Nursery

The new building was completed by July 1962, but after a short time it was found that the area for hardening was inadequate and a further extension was made later in the year. The structure as extended measures 90 ft. x 70 ft. and consists essentially of a steel frame building which is covered with "Sarlon" plastic shade cloth. All uprights are spaced on a 10 ft. square grid pattern so that the framework of the roof is a 10 ft. grid of 1 in. pipe. On this framework wire mesh is laid in 6 ft. strips over the entire roof area and over this again is the shade cloth. One area of the nursery measuring 90 ft. x 40 ft. is covered with 81 per cent. shade cloth and the remaining 90 ft. x 30 ft. with 52 per cent. shade cloth. The former is used for a propagating section and the latter for a hardening section. Overhead mist sprays are distributed throughout the entire area.

Light intensity measurements were recorded with a photometer under both areas of shade cloth during the period 20 September 1962 to 16 November 1962 at several different times of the day. The following results are means of recordings taken on thirty different occasions.

(a) Under 81 per cent. shade cloth, mean light intensity was 28.77 per cent. of external light intensity, i.e. 71.23 per cent. shade. Recordings varied from 63.6 per cent. to 76.5 per cent. shade.

(b) Under 52 per cent. shade cloth, mean light intensity was 42.1 per cent. i.e. 57.9 per cent. shade. Recordings varied from 49.1 per cent. shade to 65.8 per cent. shade.

(c) Under 81 per cent. shade cloth which had been covered with a second layer of 81 per cent. shade cloth and also a layer of 52 per cent. shade cloth, mean light intensity was reduced to 10.59 per cent. i.e. 89.41 per cent. shade. Recordings varied from 78.2 per cent. shade to 94.3 per cent. shade. Side light was probably a significant variable in these readings.

(d) Under 52 per cent. shade cloth which had been covered with a second layer of 52 per cent. shade cloth, mean light intensity was reduced to 23.69 per cent. i.e. 76.31 per cent. shade. Recordings varied from 69.1 per cent. shade to 81.2 per cent. shade and side light was again a significant variable.

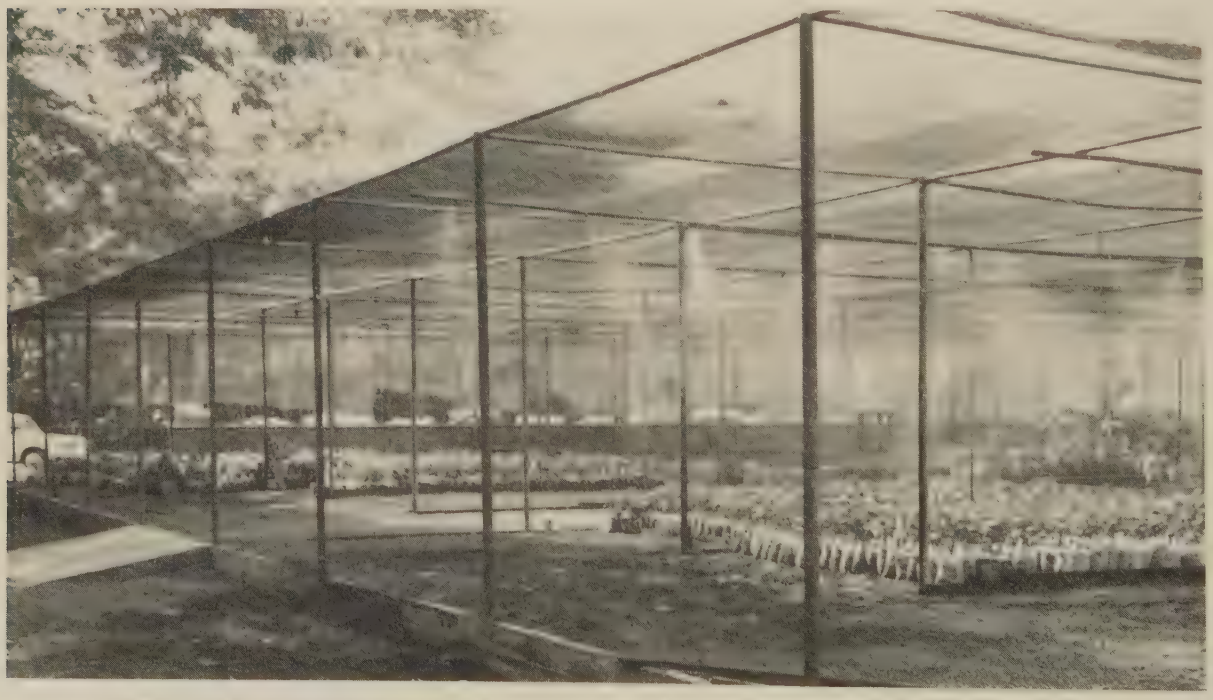

Plate 10. The new propagating nursery at Keravat, showing the hardening floor in the foreground and propagating bins in the background. (*Photo: P. N. Byrne*)

Box Propagation

Tests were made of polythene tubs as a replacement for the wooden boxes previously used, as the latter need frequent replacement and are therefore expensive in the long run. Percentages of cuttings struck for various clones tested in the polythene tubs were as good as, or better than, in the wooden boxes. Although initial cost of the tubs was three times that of the wooden boxes, they could be expected to last at least ten times as long.

The box progagation technique was continued in the new nursery from August to November 1962, and three small trials were made to establish the optimum light intensity within the boxes.

In Trial A, three clones, KA5.104, K6.101 and K23.102 were used for testing the effect of four different covers spread directly on top of the glass lids of the boxes. These covers were—

(a) 81 per cent. sarlon shade cloth

(b) 52 per cent. sarlon shade cloth

(c) Dish cloth material with a small mesh

(d) Dish cloth material with a large open mesh.

Each of the cover treatments was replicated four times on clones KA5.104 and K6.101 and three times on clone K23.102. A box containing 30 cuttings represented one replicate of each treatment for each clone. Percentages of cuttings struck under each cover are shown in Table 52.

TABLE 52. PERCENTAGE STRIKING OF CACAO CUTTINGS UNDER DIFFERENT SHADE INTENSITIES (TRIAL A)

Clone	*81 per cent. Shade Cloth*	*52 per cent. Shade Cloth*	*Small Mesh Cloth*	*Large Mesh Cloth*
KA5.104 ..	95	80	91	90
K6.101 ..	95	87	84	92
K23.102 ..	75	43	71	63
Mean ..	88	70	82	82

Light intensity measurements were not recorded.

Plate 11. Dipping cacao cuttings in hormone solution before placing in the propagating box. *(Photo: D.I.E.S.)*

In Trial B, three clones were again used for testing the effect of the same four covers as used in Trial A. Each of the cover treatments was replicated four times on clones K23.103 and K50 and three times on clone K23.102. A box containing 30 cuttings represented one replicate of each treatment for each clone. Percentages of cuttings struck under each treatment are shown in Table 53.

TABLE 53. PERCENTAGE STRIKING OF CACAO CUTTINGS UNDER DIFFERENT SHADE INTENSITIES (TRIAL B)

Clone	*81 per cent. Shade Cloth*	*52 per cent. Shade Cloth*	*Small Mesh Cloth*	*Large Mesh Cloth*
K23.103 ..	82	90	50	84
K23.102 ..	71	79	35	69
K50 ..	83	73	67	72
Mean ..	80	81	52	72

Light intensity measurements were recorded by photometer at the beginning and end of the trial. Under the microclimatic conditions operative in the nursery, algal growth on both the covers and glass tops of the propagating boxes caused reduction in light transmission as the trials progressed. At commencement of Trial B all covers and glass tops were thoroughly washed and scrubbed clean, but by the end of the trial algal growth was considerable. The measurements recorded are shown in Table 54, each recording representing the mean of eleven light intensity readings for each shade treatment: i.e. one reading was taken in each box.

TABLE 54. PERCENTAGE LIGHT IN PROPAGATING BOXES AT START AND FINISH OF TRIAL B

Cover	*Start of Trial*	*Finish of Trial*
1. 81 per cent. shade cloth ..	6.80	4.93
2. 52 per cent. shade cloth ..	10.75	7.39
3. Small mesh cloth ..	2.05	0.42
4. Large mesh cloth ..	9.05	6.00

In Trial C, three clones were used to test again the effect of three of the covers.

(a) 81 per cent. sarlon shade cloth.

(b) 52 per cent. sarlon shade cloth.

(c) Dish cloth material with a large open mesh.

Each cover treatment was replicated four times on clones KA5.104 and K20 and six times on K4. One box of 30 cuttings represented one replicate of each treatment of each clone.

As in Trial B, light intensity measurements were taken inside each box of cuttings for each clone under the three cover treatments. Hence in Table 55 each light intensity measurement represents a mean of fourteen readings. Before starting Trial C all covers were again thoroughly washed and scrubbed to remove algal growth. Light readings were recorded five days after the trial began and also at its completion.

TABLE 55. PERCENTAGE CACAO CUTTINGS STRUCK AND PERCENTAGE LIGHT UNDER THREE DIFFERENT COVERS

	81 per cent. Shade Cloth	*52 per cent. Shade Cloth*	*Large Mesh Cloth*
Percentage Strike—			
K4	95.0	92.8	89.4
KA5.104 ..	95.0	95.8	96.7
K20	95.8	95.8	96.7
Mean	95.2	94.5	93.6
Percentage light—			
After 5 days ..	5.1	8.0	6.7
At finish ..	3.5	5.6	7.6

Although the results from the three trials are variable they indicate that a high percentage of cuttings can be struck with a light intensity of up to 10 per cent. in the propagating boxes at the beginning of the propagating period. As the object is to strike cuttings under as high a light intensity as possible, so as to reduce the degree of shock which the plant receives when transferred from the propagating box to the hardening area, further trials with higher light intensities were planned. However, the system of open bed mist propagation as described below had in the meantime been proven and adopted as standard nursery procedure and the work on box propagation was not continued.

Open Bed Propagation Under Mist Spray

Formal replicated trials on open bed propagation of cacao cuttings under mist spray were not carried out prior to the adoption of this system. However, a series of small trials in the latter part of 1962 gave a sufficient guide to the practicability of the technique and it was therefore put into full use immediately.

During the construction of the nursery, a series of concrete walled beds 38 ft. long x 7 ft. wide x 18 in. deep had been built for the initial purpose of supporting the propagating boxes on 2 in. pipe bearers, and secondarily for use as propagating beds.

These beds are in the section covered with 82 per cent. shade cloth. For open bed propagation the bearers were removed, the beds filled with sawdust and an overhead spray system installed.

Briefly, the technique used is as follows:

(1) "Two leaf" cuttings are prepared, dipped in rooting hormone and inserted into the large beds of sawdust.

(2) Cuttings remain in these open sawdust beds for a period of three weeks during which they are subjected to a fine mist spray from 7 a.m. to 4 p.m. daily. The overhead 1 in. pipes carry the sprayline system at a height of approximately 8 ft. above the beds and spray is ejected through 0.031 in. Rega No. 1 spray nozzles fed from a 25,000 gallon tank with a head of 123 ft. above the nursery. Spray lines are spaced at 10 ft. intervals and the spray nozzles at 3 ft. intervals on each line at alternating angles of 45 degrees from the vertical.

(3) After the root system has developed, cuttings are removed and potted in plastic bags, using as potting mixture the mulch of topsoil, leaf litter and twigs which accumulates beneath the leguminous cover *Mimosa invisa*. Potted cuttings are held in the hardening section (under 52 per cent. shade cloth) for a further three weeks and the frequency of watering is gradually reduced. During this period the first flush of new leaves to be produced by cuttings develops and hardens. They are then moved out to shaded holding areas prior to distribution.

With this system, the eight long propagating beds in the nursery could produce a total of approximately 150,000 cuttings per annum. Allowing for 65 per cent. recovery, potential annual production is therefore approximately 100,000 cuttings.

In order that the increased number of cuttings produced from the open beds might be accommodated in the hardening section, an extension to this area was made, increasing its size from the original 90 ft. x 20 ft. to 90 ft. x 30 ft. This established the ratio of propagating area to hardening area as 4 : 3.

Reduction of Root Development Period

Mention has been made in the foregoing section of the thee week period for which cuttings are held in sawdust beds under mist spray for root development. Should it be possible to reduce this period, the potential production from a given number of beds could be correspondingly increased because of faster turnover. This matter is currently under investigation, but results from only one small trial are yet available.

Cuttings from four clones were held for the normal three to three and a half week period under spray to represent the control or standard procedure. At the same time another set of cuttings from the same clones were removed at fourteen days, at which time root development had just begun. Both lots of cuttings were potted and hardened in the normal way. Results are shown in Table 56.

Trials will continue, to establish whether a two week period in the sawdust beds is consistently satisfactory.

TABLE 56. EFFECT OF TWO DIFFERENT PERIODS OF ROOT DEVELOPMENT OF CACAO CUTTINGS

Clone	*Control (Three Weeks)*			*Two Week Rooting Period*		
	Cuttings Inserted	*Successfully Hardened*		*Cuttings Inserted*	*Successfully Hardened*	
		Number	*Per cent.*		*Number*	*Per cent.*
KA5.104	441	282	64	400	301	75
K23	423	241	57	100	70	70
KA2.105	215	150	70	211	156	74
K23.103	197	114	58	237	130	56
K23.103	..	..	..	551	313	57
Total	1,276	787	61.7	1,499	970	64.7

Distribution of Rooted Cuttings

Distribution of cuttings to other centres of the Territory presents a number of problems. They cannot be forwarded in soil, because of the danger of distributing eggs of the giant snail, *Achatina fulica.* Therefore speedy transport is essential, generally necessitating air-freighting, so that limitation of weight becomes a prime consideration. Trials were carried out aiming to establish a method of packing cuttings which would give 100 per cent. survival after up to five days transportation, with minimum weight of packing. The following methods were tried—

(a) Bare root hardened cuttings packed in bundles and despatched immediately.
  (i) Cuttings packed in plastic bags with sawdust, bag tied, tops free.
  (ii) Cuttings packed in plastic bags with vermiculite, bag tied, tops free.
  (iii) Cuttings packed in sawdust and wrapped in brown paper, bag tied, tops free.
  (iv) Cuttings packed in plastic bags containing 100 ccs. of water, bag tied, tops free.

All four treatments were complete failures. Cuttings were unpacked after seven days and planted out with very little success. The best of the treatments was number (iv) and this was amended so that the bundles were suspended in a framework in such a way that the bag hung freely from the tie at the neck. In this way the water was held in the bottom of the bag and did not come into contact with the roots to the same extent as in method (iv) where bundles were packed horizontally. Cuttings held for seven days in this manner gave approximately 75 per cent. survival.

(b) Bare root hardened cuttings packed in bundles and held under mist spray for seven days prior to despatch.
  (i) Cuttings packed in coconut fibre dust and hessian.
  (ii) Cuttings packed in sawdust and hessian.

Treatment (i) gave 82 per cent survival and treatment (ii) gave 95 per cent. survival after seven days.

Further tests were make to modify treatment (ii), and the system now used as standard entails wrapping cuttings in groups of twelve in sawdust and hessian bundles. These are held under mist spray for seven days prior to distribution and then shipped in waxed cardboard tent-roofed nursery containers with carrying handles. Each container measures 18 in. x 15 in. x 19 in. deep (not including the sloping top) and is made from No. 2 Board waxed on both sides.

Two trials were carried out during the year to test the effect of spray treatment time in the nursery against survival rate.

In the first trial, 50 cuttings of clone K4 were held under the mist spray for periods of one to seven days. Cuttings were wrapped in bundles of ten so that each treatment was represented by 5 bundles. At the end of the specified time under mist spray, cuttings were held for five days in cardboard cartons in the nursery shed to simulate a five-day travelling period. They were then repotted and held for three days under mist spray before shifting out under *Leucaena* shade. Results are shown in Table 57.

TABLE 57. SURVIVAL OF BUNDLED CACAO CUTTINGS AFTER DIFFERENT PERIODS UNDER MIST SPRAY

Number of Days under Mist Spray	*Number of Cuttings*	*Per cent. Survival at Re-potting**	*Per cent. Survival after Re-potting*
1	50	100	80
2	50	100	94
3	50	100	92
4	50	100	86
5	50	100	92
6	50	100	98
7	50	100	98

* On re-potting after holding for five days, some cuttings had de-foliated, but were still alive.

The indications from this first trial were that a 2-3 day holding period under mist spray was practically as effective as a 6-7 day holding period. Consequently a second trial was carried out along similar lines to the first using four clones and restricting spray period treatments to 2, 4 and 6 days. Cuttings were again held in cartons for a five-day period following spray treatment to simulate the shipping period. They were then potted out. Results are shown in Table 58.

TABLE 58. SURVIVAL OF BUNDLED CUTTINGS OF FOUR CACAO CLONES AFTER DIFFERENT PERIODS UNDER MIST SPRAY

Treatment	*Clone*	*Spray Period*	*Number Cuttings*	*Number Surviving with Leaves 1 Week after Re-potting*	*Mean Survival*
		days			Per cent.
1	K4	2	50	14	
2	KT82	2	50	22	
3	K6.101	2	50	15	40.5
4	KA5.104	2	50	30	
5	K4	4	50	34	
6	KT82	4	50	38	
7	K6.101	4	50	40	71.5
8	KA5.104	4	50	31	
9	K4	6	50	48	
10	KT82	6	50	44	
11	K6.101	6	50	37	83.0
12	KA5.104	6	50	47	

From this trial it was concluded that bundled cuttings should be held for a six-day period under mist spray prior to shipment. This requirement was incorporated into standard nursery practice.

Reports were subsequently received that two lots of cuttings handled in this way had suffered heavy leaf fall during shipment to another Territory centre or in the first week after repotting on arrival. Testing of the potting medium used showed no weakness. Consequently, trials are being carried out to test the effect of daily nutrient solution sprays on the leaves during the seven-day holding period and just prior to shipment to see if this will prevent leaf fall after the cuttings are despatched. Indications so far are that four applications of 1 per cent. " Aquasol " spray during the seven-day holding period are beneficial. The nutrient solution was applied at 4 p.m. after overhead sprays had been turned off for the day.

Production of Cuttings 1962-63

Table 59 lists the number of cuttings which passed through the nursery during the twelve month period July 1962 to June 1963.

The table includes all cuttings which were struck for distribution to growers, cuttings used in trials associated with improvement of nursery techniques and cuttings which were propagated for use in station trials, seed gardens, &c. Some of these latter cuttings were especially difficult to propagate and percentage recovery was extremely low.

In July 1962, propagation was still being carried out in the old nursery. For the following four months August to November 1962, all cuttings were produced by the box propagation technique in the new nursery and from December onwards open bed propagation under mist spray had been fully adopted. Although a comparison between the results for one month in the old nursery (July) and subsequent results in the new nursery would not be valid, the differences between box propagation in the new nursery and open bed propagation are quite interesting. It can be seen from Table 59 that the figures for monthly intake of cuttings, number struck and number hardened per month, all increased with the system of open bed propagation. Further, the percentage of cuttings struck increased from 75 per cent. in boxes to 85 per cent. in open beds while the percentage of cuttings successfully hardened remained the same.

The actual number of cuttings which were successfully propagated each month has averaged 5,353 since the commencement of open bed propagation.

TABLE 59. CACAO CUTTINGS STRUCK AND SUCCESSFULLY HARDENED AT KERAVAT, JULY 1962–JUNE 1963

Month	*Cuttings Inserted*	*Cuttings Struck*		*Cuttings Hardened*	
		Number	*Per cent.*	*Number*	*Per cent.*
1962—					
July ..	3,280	1,224	38	670	20
August ..	3,962	2,393	60	1,810	46
September	3,634	2,511	69	2,041	56
October ..	6,247	4,919	79	4,125	66
November	3,784	3,461	91	3,266	86
August to November Mean ..	4,407	3,321	75	2,810	64
December	9,409	8,812	93	7,553	80
1963—					
January ..	9,588	7,349	76	6,272	66
February ..	10,434	9,046	86	7,144	69
March ..	6,241	5,340	85	1,859	30
April ..	7,046	6,132	87	4,903	70
May ..	10,549	8,736	83	5,959	57
June ..	5,618	4,427	79	3,785	62
December to June Mean ..	8,412	7,120	85	5,353	64
Total ..	79,792	64,350	80	49,387	60

TABLE 60. CUTTINGS OF SELECTED CACAO CLONES STRUCK AND SUCCESSFULLY HARDENED AT KERAVAT, JULY 1962 TO JUNE 1963

Clone	*Cuttings Inserted*	*Cuttings Struck*		*Cuttings Successfully Hardened*	
		Number	*Per cent.*	*Number*	*Per cent.*
K50 ..	4,824	4,130	86	3,659	76
KT82 ..	9,270	8,747	94	7,345	79
K23.102 ..	4,405	3,366	77	2,403	54
K28 ..	1,211	987	81	757	62
K23.103 ..	3,326	2,751	82	2,499	75
K25.101 ..	280	180	64	175	60
K17.101 ..	1,827	1,426	78	1,176	65
KA2.101 ..	787	671	85	611	77
K11 ..	833	525	63	435	52
K27.102 ..	4,071	3,268	80	2,674	66
KA5.104 ..	10,379	9,305	89	7,396	71
KA2.105 ..	886	605	68	256	29
K20 ..	6,234	5,214	83	3,852	62
K6.101 ..	4,447	3,311	74	2,268	51
K24.103 ..	1,339	1,173	88	1,019	76
K25.102 ..	1,418	1,162	83	1,005	71
K19.101 ..	1,810	1,133	62	871	48
K23 ..	6,101	5,071	83	2,336	38
KA5.103 ..	3,354	2,890	86	1,972	59
Total ..	66,802	55,915	84	42,709	64

To some extent this figure is disappointing but the main limitation lies in the availability of material from the nursery lines. This will improve with time so that monthly output should also improve.

There is also an obvious need to improve the percentage of cuttings which are successfully propagated and work on this problem has been initiated. At present two factors appear to be critical—light intensity, which at 42 per cent. may be too high, and the potting medium which at times is in such limited supply that admixture with forest topsoil has been necessary, to the detriment of the cuttings being hardened.

Data for all clones on the distribution list which were propagated in 1962-63 are shown in Table 60. The figures include cuttings propagated in the old nursery and in boxes and open beds in the new nursery, and serve to illustrate the variability between clones in ease of propagation.

COCONUTS

Progress was good in most of the trials with mature palms, but unfortunately the same cannot be said for trials with new seedlings. It appears that for success in trials where new plantings have to be made, some new approach will be necessary. At Keravat the dynastid problem at present seems insurmountable. The Seed Sources Trial was planted in an isolated block at a few hundred feet above sea level, where it was thought that beetle damage would not be serious. The move was fully successful in escaping from *Oryctes* but a complete failure with *Scapanes*. Some observations now suggest that *Scapanes* damage is usually serious only in the immediate vicinity of forest land, and the new block opened up for this trial is completely surrounded by primary forest.

In trials on outside plantations the main problem was lack of constant supervision by an agronomist, although dynastid damage was also quite serious. With an agronomist visiting the trials only once every six months it was not possible to ensure adequate maintenance and attention to special needs as required, and also it was often necessary to transplant seedlings at times when neither the seedlings nor the weather were at their best.

FERTILIZER TRIALS

TCN2. Yellow-Brown Clay Loam, New Ireland

This trial was originally comprehensive, involving all major and minor elements, but after 1959 potassium fertilizer only was applied to four groups of 32 palms each. Two of these groups had received potassium fertilizer in the original treatments, and two had not. Details of quantities of muriate of potash applied throughout the trial are shown in Table 61.

TABLE 61. TCN2. YELLOW-BROWN CLAY LOAM COCONUT FERTILIZER TRIAL

QUANTITIES AND DATES OF FERTILIZING WITH MURIATE OF POTASH

Treatment	*Date Applied*				
	11/55	*11/57*	*11/59*	*11/61*	*1/63*
	lb.	lb.	lb.	lb.	lb.
A ..	5	5	10	8	8
B ..	5	5	0	0	0
C ..	0	0	10	8	8
D ..	0	0	0	0	0

Plots in this trial are of a single tree, with no guarding. In 1955 and 1957 fertilizer was placed very close to the bases of the palms to avoid poaching between treatments, and clear response to potassium was evident. However, by 1959, other trials had shown that this placement was not ideal, and later dressings were spread over a larger circle extending to ten feet or more from the bases of the palms.

Yield estimates (average numbers of nuts per palm, counted every six months) are shown in Table 62.

TABLE 62. TCN2. YELLOW-BROWN CLAY LOAM COCONUT FERTILIZER TRIAL

YIELD ESTIMATES—NUMBERS OF NUTS PER PALM

Treatment	*11/61*	*5/62*	*1/63*	*6/63*
A	32	36	41	32
B	34	33	39	30
C	28	30	39	28
D	28	29	38	29

These results seem inconsistent with those obtained earlier, as they fail to show a consistent response to potassium. However, it was noted in June 1963, that all palms, regardless of treatment, were of a better colour than palms outside the trial block. It is very probable that the wider fertiliser placement mentioned above permitted extensive poaching between treatments so that there were no longer any effective controls.

Since the trial has fulfilled its main diagnostic purpose, it will be discontinued.

TCN4. Potash Rate of Application Trial, New Ireland

Average nut numbers at four counts between May 1961 and January 1963, are shown in Table 63. These numbers have been adjusted by covariance analysis for pretreatment yield.

TABLE 63. TCN4. POTASH RATE OF APPLICATION TRIAL ON COCONUTS

NUMBERS OF NUTS PER PLOT (ADJUSTED)

Treatment	*5/61*	*11/61*	*5/62*	*1/63*
0	168	174	150	148
2½ lb. KCl per palm per year ..	259	275	266	255
5 lb. KCl per palm per year ..	284	276	290	282
10 lb. KCl per palm per year ..	274	324	292	273

The lowest rate continues to look the most promising.

TCN3. Potash Method of Application Trial, New Ireland

Average nut numbers at three counts between May 1961 and May 1962, are shown in Table 64. These have been adjusted by covariance analysis for pretreatment yield.

TABLE 64. TCN3. POTASH METHOD OF APPLICATION TRIAL ON COCONUTS

NUMBERS OF NUTS PER PLOT (ADJUSTED)

Treatment	*5/61*	*11/61*	*5/62*
Control	129	140	118
Narrow band, biennial ..	181	155	139
Broad band, biennial ..	219	192	188
Broad band, annual ..	216	195	175

Counts at January and June 1963 showed fairly similar trends, all fertilizer treatments being much superior to the control and the broad band biennial application being, on the average, better than the other two methods. This result, together with results of TCN4, have led to a confident recommendation for fertilizing with muriate of potash at 5 lb. per palm every second year on areas in New Ireland where deficiency symptoms are evident.

TCN5. Potash Fertilizer Trial With Seedlings, New Ireland

The seedling fertilizer trial in New Ireland was superimposed on the Replanting Trial, which was discontinued in 1963. Detailed results of the whole trial will be published in *The Papua and New Guinea Agricultural Journal.* Up to the time when damage to seedlings rendered the results unreliable there was a consistently increasing response to the potassium fertilizer, and it is likely that on soils of this type fertilizing would be not only beneficial but virtually essential for successful raising of coconut replant seedlings.

TCN12. K-NPK-Cultivation Trial, New Ireland

The need has been felt for a new trial to confirm and clarify the results of existing trials. During 1963, a suitable block of palms was selected on a fairly level area of yellow-brown clay loam soil. Palms are about 30 years of age planted 30 ft. triangle and show typical potassium deficiency symptoms, with variability from fair to very poor which is characteristic on this soil type. Unlike the other trials, the block has few palms missing. The area is interplanted with cacao and *Leucaena glauca* shade, with two age levels in the cacao.

There are to be five main treatments as follows—

1. Control.
2. Cultivation.
3. Potassium fertilizer.
4. Potassium fertilizer with cultivation.
5. NPK fertilizer with cultivation.

The cultivation operation will coincide with fertilizing and will be aimed primarily at turning the fertilizer into the soil. Treatment 2 is thus a control for the method of fertilizer application comparison. Potassium fertilizer will be applied at the rate of 5 lb. muriate of potash biennially. The NPK fertilizer will be high in K (such as 17:11:22) and will be applied at a rate to give the same amount of K as the potassium treatment.

In addition, the main plots will be split for a comparison between two methods of fertilizer placement.

(a) Broadcast in a ring around the base of the palms, of diameter about 15 ft.
(b) Broadcast uniformly over the whole area between palms.

In June 1963, the plots were marked out and pretreatment nut counts were made. Further nut counts will be made after six months and the treatments will then be applied. Plots are of 7 x 7 trees for treatment applications, with a single row of palms left as a common untreated guard between plots. For assessment of results an inner plot of 5 x 5 trees will be considered. For the sub-treatments in the fertilized plots, these will be divided into two plots of 5 x 2 with a common guard between them.

At the time of marking out, nut water and soil samples were taken for analysis, and half nuts were weighed. Results are summarized in Table 65.

TABLE 65. TCN12. K-NPK-CULTIVATION TRIAL ON COCONUTS

Pre-treatment Yield Estimates and Mineral Contents of Nut Water

Plot No.	Numbers of Palms	Total Nut Counts	Number Nuts Sampled	Av. Wt. (lb.) Meat and Shell	Nut Water Mineral Content (m. equiv./litre)		
					K	Na	Ca
1	25	340	14	0.8	18	40	9
2	25	333	18	1.0	14	34	8
3	25	288	11	0.8	12	42	8
4	25	535	19	1.1	16	35	8
5	25	398	18	0.9	19	28	9
6	24	315	16	1.0	19	32	9
7	24	237	16	1.0	18	31	9
8	24	301	11	1.0	11	32	7
9	23	418	11	1.0	15	35	7
10	25	305	14	0.9	13	32	9
11	23	298	12	1.0	18	45	8
12	22	186	9	0.9	7	27	10
13	24	317	13	1.0	11	31	8
14	22	473	9	1.1	20	27	10
15	25	367	17	1.0	16	34	10
16	23	440	13	0.9	10	40	7
17	25	385	15	0.9	8	38	8
18	23	249	10	1.1	14	33	10
19	24	413	16	1.0	17	36	10
20	21	253	15	1.1	12	29	8

Results of soil analyses are not yet available, but nut water analyses indicate a very low potassium status. The average nut water K content is lower than the pretreatment level in any of the earlier trials, but this may be partly a seasonal effect. There had been a very dry period in early 1963 and below average rainfall prior to that, and it is likely that nut numbers and potassium status both were lower than usual at the time of sampling.

TCN7. Black Sand, Papua

No further fertilizer was applied to the block, nor were nut counts made, but the palms in the block continued to show better colour than the surrounding palms. The same sort of improvement has also been observed where cattle have been yarded at night.

Palms to which 3 lb. sulphate of ammonia had been applied in October 1960, showed no improvement in colour in April 1962. A further 3 lb. per palm was applied in April 1961, to some of these palms and to others not previously treated, but these also showed no response in April 1962.

In April 1962, samples of fallen button nuts from four locations within the area were collected for chemical analysis. The number of samples was small, but results did indicate nitrogen as a likely deficient element (*see* Table 66).

TABLE 66. TCN7. BLACK SAND COCONUT FERTILIZER TRIAL, PAPUA

Chemical Analysis of Fallen Button Nuts from Palms near the Trial Block

	N	P	K	Ca	Mg
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Site 1—Palms yellow ..	0.86	0.18	2.67	0.13	0.15
Site 2—Palms yellow ..	1.01	0.22	2.96	0.13	0.20
Site 3—Palms green ..	1.29	0.19	2.83	0.13	0.19
Site 4—Palms green ..	1.22	0.22	2.78	0.13	0.18

The lack of a clearcut response to nitrogen in the fertilizer trial may have resulted from poaching between treatments, and from rapid leaching of inorganic nitrogenous fertilizer in this sandy soil. It is of interest to note that the apparent nitrogen deficiency has not been corrected by a fairly vigourous cover-crop of the legume *Pueraria*.

TCN10. Alluvial Brown Loam, Papua

As stated in the 1960-61 Annual Report, the original trial on mature palms has been discontinued. However, a new trial was commenced on seedlings in the replanting trial on the same plantation. The soil is of the same type as in the original trial, but as

the replanting trial covers an area of almost 40 acres, there is some variability in fertility as indicated by yields of the standing palms and growth of the replants prior to fertilizing.

The replanting trial contains 4 replicates of 5 treatments, thus 20 plots. Each plot contains 30 trees, in 6 rows of 5 trees each. Because of this layout, the rows were used as fertilizer sub-plots, giving 20 replications of 6 treatments. As there had been many replacements amongst the replant seedlings, they varied in age from nil to three years at the time of fertilizing, and consequently there was much variation within the replicates in number and size of seedlings assigned to each fertilizer treatment. The treatments, therefore, were first assigned at random within each replicate and then some rearrangements made so that, over all, total numbers of good seedlings and total size of seedlings were approximately the same for each fertilizer treatment.

Preliminary foliar analysis on samples collected in 1960 had indicated nitrogen and potassium as the most likely deficient elements, so the treatments used were—

Control
N
P
K
NK
NPK

These were superimposed on the five thinning treatments of the replanting trial, so that there were in effect 4 replicates of 30 treatments. Leaf samples (central leaflet of youngest fully open leaf) were taken in May 1961, prior to fertilizer application, and were bulked from the four replicates for analysis. Results are summarized in Table 67. These showed fair uniformity between seedlings assigned to the different treatments, and also indicated that the thinning treatments had little effect on mineral content of the seedling leaves. There was a possible suggestion of decrease in K with increasing exposure.

Because of staff difficulties the fertilizer was not applied till 30th October 1961. Rates used were varied according to the size of the seedlings, the aim being to spread fertilizer at a uniform rate over the drip-circle of the seedlings. The maximum used on well grown seedlings was N as 12 oz. sulphate of ammonia, P as 12 oz. superphosphate and K as 8 oz. muriate of potash. The drip circle of the palms was clean weeded prior to fertilizing. A second fertilizer application was made on the same basis in April 1963.

Further leaf samples were taken for analysis in May 1962, and results of this sampling also are shown in Table 67. The only evidence of fertilizer uptake was in the treatments including K, and uptake was only slight ($K_0 = 1.14$ per cent. K, $K_1 = 1.34$ per cent. K).

TABLE 67. TCN10. COCONUT FERTILIZER TRIAL ON ALLUVIAL BROWN LOAM

FOLIAR ANALYSIS. SUMMARY OF AVERAGE LEAF CONTENTS, BY TREATMENTS

Treatment	*Pre-Treatment May 1961*				*Post-Treatment May 1962*				
	N	*P*	*K*	*Ca*	*N*	*P*	*K*	*Ca*	*Mg*
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Control	1.99	0.20	1.02	0.16	1.97	0.19	1.19	0.25	0.34
N	1.83	0.20	0.97	0.14	2.01	0.17	1.15	0.27	0.38
P	1.88	0.19	1.10	0.22	1.84	0.18	1.08	0.25	0.38
K	1.83	0.20	1.09	0.25	1.90	0.17	1.27	0.25	0.33
NK	1.86	0.19	1.00	0.28	1.95	0.17	1.29	0.25	0.37
NPK	1.89	0.19	1.12	0.34	1.96	0.18	1.45	0.23	0.34
No thin	1.93	0.20	1.28	0.26	1.87	0.18	1.63	0.27	0.37
¼ thin	1.88	0.19	1.07	0.20	1.91	0.18	1.26	0.25	0.35
½ thin	1.84	0.19	0.95	0.23	1.98	0.18	1.10	0.25	0.37
¾ thin	1.88	0.20	1.01	0.23	1.96	0.18	1.11	0.24	0.35
Full thin	1.88	0.20	0.93	0.25	1.97	0.17	1.09	0.24	0.35
General mean ..	1.88	0.20	1.05	0.23	1.94	0.18	1.24	0.25	0.36

Lack of uniformity in the original seedlings and damage to many of them during the course of the expriment leads to some difficulty in assessing the results. Accordingly, growth measurements have been assessed in two ways—averages for all surviving seedlings, and averages for those seedlings which had not suffered any severe damage during the period. A summary of these results in shown in Table 68.

TABLE 68. TCN10. COCONUT FERTILIZER TRIAL ON ALLUVIAL BROWN LOAM

SEEDLING GROWTH INCREASES

——	*Cont.*	*N*	*P*	*K*	*NK*	*NPK*
Height Increase (in.) Apr. '61–Nov. '62—						
A	90.6	94.4	91.6	97.5	102.3	101.2
B	97.0	103.7	94.4	101.7	105.6	109.4
Number New Leaves Oct. '61–Apr. '63—						
A	12.4	12.6	12.6	12.6	12.8	13.0
B	12.8	12.8	13.0	13.0	13.0	13.0

A—average for all seedlings. B—average for undamaged seedlings only.

The results indicate a possible reponse to N and K, but variability within treatments was great and the differences would not be statistically significant.

CULTURAL TRIALS

TCN8. Cultivation Trial, Papua

Following sale of the Government Plantation where this experiment is sited, treatments were discontinued and the method of yield recording was varied to an annual count of nuts on a sample of the palms. Up to April 1962 nuts had been collected and counted from the ground after natural fall. The last cultivation treatment was given in October 1963, making four times that the full ploughing was applied.

Yield records are shown in Table 69.

TABLE 69. TCN8. CULTIVATION TRIAL, PAPUA

NUTS HARVESTED JANUARY 1961 TO APRIL 1962, AND COUNT OF NUTS ON PALMS, NOVEMBER 1962

Treatment	*Nuts Harvested*		*Nuts per Palm, November 1962*
	Jan.–Dec. 1961	*Jan.–Apr. 1962*	
Control ..	9,592	3,594	25.2
Full plough ..	10,263	3,992	24.8
Strip plough ..	9,510	3,719	27.4

The 1961 figures indicated some benefit from the full ploughing treatment. To examine this more closely, an analysis of variance was made on nut numbers for the 12 month period April 1961 to April 1962, which allowed for a lag of 12 months between first ploughing and resultant increase in yield. This analysis indicated response significant at 5 per cent. (*see* Table 70).

TABLE 70. TCN8. CULTIVATION TRIAL, PAPUA

YIELDS APRIL 1961–APRIL 1962

Treatment	*Nuts/Plot*	*Nuts/Palm*
Control	2,686	74 6
Full plough	2,941	81.7
Strip plough	2,682	74.5
L.S.D. 5 per cent. ..	202	5.6

However, the apparent lack of response in the yield estimates at November 1962 leaves it doubtful whether the earlier result was more than a chance increase. In any case, the yield increase of less than 10 per cent. would not be economic.

TCN10. Replanting Trial, Papua

Heavy losses of replant seedlings occurred during 1961-62 as a result of widespread waterlogging. Although there had been some losses before, this was the first time since the commencement of the trial that there was a severe prolonged wet period and low-lying areas were brought to light. It was of interest to note that despite 100 per cent. mortality of seedlings in some patches, mature palms in the same patch showed little more effect than a yellowing of the fronds. Many of the seedlings which died had previously been making very good growth. Damage tended to be localized with the result that certain plots were particularly hard hit. In one plot

(of 30 trees) 9 were killed and 14 damaged. In addition to the waterlogging, there was considerable dynastid damage. Out of the 600 seedlings for which records are kept, 47 were damaged in October 1961 and 80 in April 1962, but subsequently damage decreased slightly.

The dynastid damage (*see* Table 71) differed markedly between replicates as well as between treatments, indicating that damage was non-random as regards locality. There was almost certainly a real treatment effect also, the insects showing a preference for the unthinned plots. It is doubtful whether this has any practical significance. Given the choice they seem to prefer unthinned areas, but it is likely that if all old palms had been removed from the whole area, damage would not have been any less. In the Seed Sources Trial at Keravat beetles certainly show no objection to the open spaces.

Some of the growth measurements made on the seedlings are summarized in Table 71. The figures quoted for average number of leaves are based on the total number of leaves produced from planting until April 1963, drawn from records made every six months of all new leaves produced. Dynastid damage records the number of palms noted as damaged, out of a total of 120 in each treatment.

The only growth difference between treatments showing any consistency is that of number of leaves produced. This would indicate some benefit from thinning, but its significance is hard to assess. It is likely that, in the treatments with old palms remaining, there is some influence of their shade on the seedlings causing them to grow taller, and thus to some extent invalidating the use of height as a measure of comparative vigour. On the measurements to date, it seems likely that retaining the old palm stand for some years after replanting would not retard the replants very substantially.

TCN5. Replanting Trial, New Ireland

During 1962 it became evident that this trial had been unfortunately sited in respect of dynastid beetle damage. The plots were on the edge of the plantation and adjacent to a swampy area, from which *Scapanes* and *Rhynchophorus* invaded the coconut seedlings. Damage was so severe that the trial was discontinued in 1963. A detailed report is being prepared for publication in the *Journal*. The results indicated that thinning of the old palms probably is not necessary for the first two to three years of seedling growth, but beyond that period results were inconclusive.

TCN11. Interplanting with Cacao, Keravat

Oryctes damage continued to be serious, and many palms also were killed by *Rhynchophorus*. Although several have now borne mature fruit, at many points seedlings have not got started at all, so there is little chance of getting anything out of the experiment. Removal of the oil palm block, where *Oryctes* breed, is progressing.

TABLE 71. TCN10. COCONUT REPLANTING TRIAL, PAPUA

GROWTH RECORDS IN 1962 AND 1963

Treatment	*Per cent. Survival*		*Dynastid Damage 4/61 to 4/62**	*Average Height (in.)*		*Leaf Numbers April 1963*
	April 1962	*April 1963*		*April 1962*	*April 1963*	
No thin	68	68	62	161	194	32.6
¼ thin	67	60	41	168	194	35.7
½ thin	58	57	21	187	205	37.3
¾ thin	48	47	9	157	194	37.3
Full thin	60	57	6	182	206	39.6

* Total numbers of seedlings recorded over three inspections.

Plate 12. Well-grown palms on Baibara Plantation, Papua, from which parent palms were chosen for progeny testing. (*Photo: A. E. Charles*)

TCN9. Progeny Trial, Papua

Heavy rains during the latter half of 1961 caused water-logging of the third replicate of this trial, with loss of most seedlings. Since it was first planted in April 1959, more than 170 replacements had been planted in the effort to establish 108 points. In view of the continuing failure of this second half of the trial, and continuing losses in the first half, no further attempt will be made to complete the experiment. However, observations on the established seedlings will be continued.

The block remained free from dynastid beetle damage and the *Pueraria* cover crop was fully established by 1962. Some slight damage was caused to the coconuts in early 1963 by cattle which were brought in to graze the covercrop.

Growth records shown in Table 72 are based only on seedlings in replicates 1 and 2 which had survived from the original planting without any severe setback from accidental damage. Heights were not recorded after April 1962 because of the difficulty of measuring leaves which sometimes reached to more than 30 ft. The numbers of leaves are averages, for each progeny, of leaves produced during the 3½ years from September 1959 to March 1963. Mother palm nut production is a total of nut numbers counted every six months between March 1957 and March 1963 (11 counts).

TABLE 72. TCN9. COCONUT PROGENY TRIAL

MOTHER PALM NUT NUMBERS, HEIGHT AND LEAF PRODUCTION OF SEEDLING PROGENY

Mother Palm No.	*Nut Numbers on Mother Palms*	*Progeny Seedlings*	
		Height (in.) April 1962	*Leaves Produced September 1959 to March 1963*
B4 ..	461	223	32.2
B5 ..	499	208	31.6
B8 ..	552	197	33.8
B10 ..	493	222	34.3
B11 ..	Dead	188	30.9
B12 ..	474	195	30.7
B13 ..	409	190	32.4
B14 ..	408	190	32.4
B17 ..	918	165	32.1

TCN1. Seed Sources Trial, Keravat

Although the few undamaged seedlings continued to grow well, dynastid beetle attack assumed major proportions during 1961 and continued unabated despite control measures. Two sprayings with 1 per cent. Dieldrin, application of Gammexane-sawdust mixture to leaf axils, treatment of wounds with creosote containing Dieldrin, and picking the insects out with sharp knives at intervals, all failed to give control. In 1963 palm weevils (*Rhynchophorus* sp.) joined the attack and killed many seedlings which might otherwise have survived the dynastid damage. Figures on survival of seedlings and damage to survivors in Table 73 give an indication of the severity of the problem.

TABLE 73. TCN1. COCONUT SEED SOURCES TRIAL

GROWTH RECORDS ON SEEDLINGS

Source of Seed	*May 1962*			*May 1963*		
	Seedlings Dead or Badly Injured	*Average Height*	*Average Leaflet Weight*	*Seedling Survival*	*Survivors with Dynastid Damage*	*Average Height*
	Per cent.	In.	Gm.	Per cent.	Per cent.	In.
Papua	30	168	18.3	56	53	169
Karkar Island	22	175	23.8	75	54	211
Madang	19	164	19.9	75	60	179
New Ireland	25	192	24.1	83	30	248
Markham	23	193	25.6	62	65	219
Bougainville	25	197	22.1	80	61	229
Hermit Islands	11	164	19.7	61	61	198
Sepik	20	161	18.9	59	63	187
Gazelle Peninsular ..	20	202	24.4	78	44	249

Appreciable success was obtained in establishment of *Pueraria* cover crop by using a layering method to establish runners in baskets of soil, which were then transferred to points throughout the block. By June 1963 a large proportion of the block had a dominantly *Pueraria* cover.

Because of dynastid damage the comparison between vigour of selected and reject seedlings would not be valid any longer. However, it may be noted that up to May 1962 deaths in the reject seedlings were 32.6 per cent., as against 18.8 per cent. in the selected seedlings.

Other growth records are summarized in Table 73. Average heights are based only on seedlings surviving from the original planting. Leaflet weights recorded in May 1962 were based on two leaflets per seedling, instead of the four included in the figure in the Annual Report for 1960-61.

Crossing of Tall and Dwarf Palms

All seedlings were severely damaged by dynastid beetles, and it is doubtful whether any will survive.

MISCELLANEOUS

Botanical Plot

Rhynchophorus weevils have now appeared in this plot, and a large proportion of palms have been killed. Though many palms were bearing, condition was very poor because of insect damage.

ROBUSTA COFFEE (*Coffea canephora*)

As a result of changes in staff and general staff shortage, work on this relatively minor crop was limited during the period under review.

Seed Production: During the two years, a total of 2,306 lb. of seed of the Besoeki strain was distributed for planting.

KCC3. Polyclonal Seed Garden—Block 303

Although initially planted in March 1958, many replacements had to be made, up to as late as May 1962. Consequently, the 144 cuttings were in varied stages, and seed could not be obtained which could be considered representative of the mature production from the garden. A reasonably representative sample should be available for testing by the end of 1963 or early 1964, and at this time danger of cross-pollination from the nearby clone-testing trial will have been eliminated as the trees have been cut back.

KCC4. Polyclonal Seed Gardens, Vunapau Road

The value of these gardens is now limited, as it is intended to restrict future planting to the Besoeki strain, and these gardens include clones of other types as well. Some replacements were made during the period, and at June 1963, trees had been pruned back heavily for conversion to the *Agobiada* system.

KCC7. Polyclonal Seed Gardens, Extension Stations

The number of these gardens has been increased to nine, and cuttings were supplied as necessary for establishment and maintenance. The older gardens have now commenced to bear, and should soon contribute appreciably to local seed requirements.

KCC6. Progeny Trial—Block 204

The site of this trial was cleared, marked out and planted with shade. Seed will be taken from the twelve clones of KCC3 when a representative sample is available, probably in late 1963 or early 1964.

KCC2. Clone Testing—Block 303

As indicated in the 1960-61 Annual Report, lack of uniformity in the trees prevented valid comparison. By June 1963, all trees had reached a good size and were therefore heavily pruned back for training on the *Agobiada* system.

KCC1. Open Pollinated Progeny Lines

As reported in 1960-61, 50 open-pollinated seedlings from each clone in the clone testing trial were planted in June 1959. As with the other trials, establishment was not very uniform, and all have been pruned back heavily for conversion from single-stem to *Agobiada* pruning system. Yield recording will be commenced when the new leaders are established.

KCC5. Spacing x Pruning Trial—Block 204

Shade has been established for the trial, but marking out and planting have not yet been carried out.

Observation Plots

KCC9. Hybrid Seed: Fifty seedlings, resulting from hand crosses between selected trees, were transplanted in May 1963, for growth and yield observation.

KCC10. Ravalien Seed: In August 1962, seed was collected from a small area of old coffee growing on Ravalien Plantation, near Kokopo, New Britain. Seed is thought to have been introduced during the German Administration period. Seedlings were transplanted in May 1963, for growth and yield observation.

ABACA (MANILA HEMP) *Musa textilis*

Economics

Abaca is not grown commercially in the Territory, but breeding and agronomic studies have been carried out with a view to its possible value for diversifying the agriculture of the country. Experimental work has reached a stage where satisfactory planting material is available and experience has been gained in the techniques of production, but the economic outlook of the crop is not currently sufficiently promising to encourage extensive planting. Consequently no efforts have been made in this direction, and the experimental programme is being tapered off to a maintenance level.

Abaca fibre has encountered increasing competition in world markets from synthetic fibres and prices showed a general downward trend from 1959 to 1962, with some recovery in late 1962 and early 1963. Price trends varied for different grades of fibre. Prices of non-Davao fibre (c.i.f. main European ports in £A. per ton) for top grade and low grade fibre were as follows:

Grade	*July 1961*	*June 1962*	*March 1963*	*June 1963*
	£ s.	£	£	£
Top grade ..	282 10	195	230	203
Low grade ..	132 10	109	165	156

A preliminary survey of costs of production and marketing was made in 1962. Data available were insufficient for the results to be more than a general guide, but they did indicate that the margin of profit was low. Costing was based on an estimate that one acre of Manila hemp would yield one ton of fibre annually, with an economic life of ten years. Based on labour usage in the Two Acre Production Trial (KMT6), planting and maintenance requirements for the two years of establishment before the crop came into production were estimated at 110 man days per acre. Subsequent maintenance through the life of the crop would be lower and was estimated at two weeks per year for a labourer, totalling 110 man-days for the ten-year period. From experience in harvesting a four-acre plot on the Station, labour requirement for harvesting and processing was estimated at 1,680 man-days per acre over ten years. This is based on harvesting four times yearly, which is desirable. Total labour requirements were thus estimated at 1,900 man-days per acre over ten years, equivalent to £69 per ton of fibre produced with labour costs at £2 per 44-hour week.

Based on the machinery used at Keravat, it was estimated that capital and maintenance costs over ten years of equipment to handle 12 acres would amount to a total of £1,459. Writing this off over the ten-year period gives a cost of £12 3s. per ton of fibre.

Cost items listed above total £81 3s. per ton, and these do not include rental of land, management, interest on capital investment, transport, operating costs of processing machinery, or baling. In addition to these production costs, marketing costs would be considerable because of the bulky nature of the product. One ton of abaca fibre, as normally baled in the Philippines, occupies 80 cubic feet, although Sumatran fibre is compressed to 62 cubic feet per ton. Even at the latter volume, freight costs from Papua and New Guinea to Australia would amount to £20 per ton at current rates.

KMT6. Two Acre Production Trial

Records of labour usage in establishing this trial were maintained and used in the estimate of production costs described above.

The clone used, KT6, failed to mature in the expected 15 month period. The first harvest was made in December 1962, when the plants were 18 months old. This was not a large harvest, and most stems were too short to warrant processing, being generally about 4 feet in length. A second harvest, in June 1963, was much larger and the stems were generally of suitable length. A total of 334½ lb. of fibre was produced from the 2 acres.

Growth over the block is uneven and disappointing. It is planned to apply fertilizer in an effort to obtain greater uniformity.

KMT1. Clone x Shade x Spacing Trial—Block 403

Yields in this trial were recorded up to the ninth harvest in June 1962. Three further harvests were not yield recorded, as the main trends were well established. Occasional records will be made later to check whether any changes become evident.

Results from the first nine harvests are shown in Table 74. It must be noted that plots at all spacings contain four hills, thus plot areas are not equal. Average yields of all clones, converted to pounds fibre per acre were: 13 ft. = 2,493 lb., 10 ft. 6 in. = 2,093 lb., and 8 ft. = 1,951 lb. The results have not yet been analysed statistically, but it is clear that there were big differences between clones. The apparent beneficial effect of early shading is surprising, in that it was still evident at the ninth harvest, long after the treatment had been applied. If real, the effect indicates that good conditions in the establishment period are vital.

TABLE 74. KMT1. ABACA CLONE x SHADE x SPACING TRIAL

YIELDS SEPTEMBER 1959 TO JUNE 1962

Clone	*13 ft. spacing** Number Stems	*13 ft. spacing** Weight Fibre (lb.)	*13 ft. spacing** Fibre Recovery (Per cent.)	*10 ft. 6 in. spacing** Number Stems	*10 ft. 6 in. spacing** Weight Fibre (lb.)	*10 ft. 6 in. spacing** Fibre Recovery (Per cent.)	*8 ft. spacing** Number Stems	*8 ft. spacing** Weight Fibre (lb.)	*8 ft. spacing** Fibre Recovery (Per cent.)
SPACING EFFECTS (YIELDS PER PLOT)									
K4	123	88	3.1	75	68	3.0	47	24	3.2
K5	117	117	2.3	83	49	2.3	50	27	2.6
K6	114	104	2.6	39	14	2.5	50	32	2.7
K7	125	116	2.9	70	54	3.5	51	36	3.0
K8	105	91	2.6	70	54	3.6	28	16	3.3
K9	92	60	2.8	69	63	3.1	27	14	2.7
K12	45	22	2.3	19	11	2.9	11	2	2.1
K14	83	107	3.1	79	78	3.2	30	8	1.7
K15	92	86	2.5	61	31	2.1	50	39	2.7
K16	42	36	2.4	28	24	2.6	15	15	2.8
K17	102	73	2.5	64	46	2.8	39	25	2.5
KT1	117	105	2.8	59	39	3.1	31	24	2.8
KT2	87	48	1.9	54	23	2.0	23	9	1.9
KT3	79	60	2.9	52	46	3.0	40	47	3.5
KT7	62	49	2.6	32	28	3.3	32	32	2.8
KT8	100	76	3.0	58	50	3.1	19	17	3.1
Total ..	1,485	1,238	2.6	912	678	2.9	543	367	2.7

Clone	*Unshaded* Number Stems	*Unshaded* Weight Fibre (lb.)	*Unshaded* Fibre Recovery (Per cent.)	*Shaded* Number Stems	*Shaded* Weight Fibre (lb.)	*Shaded* Fibre Recovery (Per cent.)	*Total* Number Stems	*Total* Weight Fibre (lb.)	*Total* Fibre Recovery (Per cent.)
SHADING EFFECTS									
K4	110	67	3.0	135	112	3.2	245	179	3.1
K5	126	92	2.3	124	101	2.3	250	193	2.3
K6	94	59	2.3	109	91	2.9	203	150	2.6
K7	120	81	3.0	126	125	3.1	246	206	3.1
K8	102	79	2.8	101	82	3.1	203	161	2.9
K9	78	55	3.1	110	82	2.8	188	137	2.9
K12	32	17	2.3	43	18	2.5	75	35	2.4
K14	80	59	2.8	112	135	3.1	192	193	3.0
K15	88	50	2.2	115	106	2.6	203	156	2.4
K16	41	35	2.7	44	40	2.4	85	75	2.6
K17	96	78	2.6	109	66	2.5	205	144	2.6
KT1	88	76	2.9	119	92	2.9	207	168	2.9
KT2	64	25	1.9	110	55	1.9	164	80	1.9
KT3	76	61	3.0	95	92	3.2	171	153	3.1
KT7	58	51	2.8	68	58	2.9	126	109	2.8
KT8	85	53	2.7	92	90	3.4	177	143	3.1
Total ..	1,338	938	2.7	1,602	1,344	2.8	2,940	2,282	2.7

* Plots of four hills at all spacings. Plot areas: 13 ft. = 676 sq. ft.; 10 ft. 6 in. = 441 sq. ft.; 8 ft. = 256 sq. ft.

KMT5. Clone Testing Trials

Trial 1—*Block* 302: Yield records of this trial were maintained up to the sixth harvest in July 1962. Average yield at this stage was only 0.3 tons fibre per acre per annum, with the best clone yielding at 0.5 tons per acre per annum. Clone KT8 in this trial did not compare well with its performance in trial KMT2, where it yielded 0.9 tons per acre. The site of the clone testing trial is not ideal for the crop, as drainage is poor in many places.

Subsequent harvests have not been yield recorded, but records will be taken from time to time in future to watch the trends. Total yields up to the sixth harvest are shown in Table 75.

TABLE 75. KMT5. ABACA CLONE TESTING TRIAL 1

TOTAL YIELDS FROM SIX HARVESTS UP TO JULY 1962

Clone	*No. of Stems*	*Weight of Stems*	*Weight of Fibre*	*Fibre Recovery*
		lb.	lb.	Per cent.
K1.. ..	470	8,988	205	2.3
K2.. ..	538	12.060	336	2.8
K3.. ..	663	12,242	359	2.9
K6.. ..	596	12,968	319	2.5
K7.. ..	582	13,293	251	1.9
K9.. ..	611	11,910	302	2.5
K10 ..	558	8,276	206	2.5
K17 ..	365	5,554	135	2.4
K21 ..	526	12,645	298	2.4
K22 ..	777	14,900	372	2.5
KT1 ..	616	9,304	249	2.7
KT3 ..	459	9,746	296	3.0
KT6 ..	578	12,460	328	2.6
KT8 ..	698	14,595	410	2.8
KT10 ..	379	6,177	163	2.6
KT20 ..	678	15,368	382	2.5
KT21 ..	628	12,293	291	2.4
KT22 ..	520	9,270	267	2.9
KT23 ..	590	12,573	344	2.7
KT24 ..	422	8,667	196	2.3
KT26 ..	551	10,323	310	3.0
KT27 ..	903	15,206	358	2.4
KT28 ..	733	10,932	260	2.4
KT29 ..	588	9,696	256	2.6
KT33 ..	434	5,383	153	2.8
Mean..	579	10,993	281.8	2.6

Trial 2—*Block* 207: This trial was planted in November 1960 and harvesting commenced in October 1962. Results of the first harvest are shown in Table 76, but although major differences between clones are indicated results from further harvests will be needed before firm conclusions can be drawn.

TABLE 76. KMT5. ABACA CLONE TESTING TRIAL 2

YIELDS OF STEMS, FIBRE, AND FIBRE RECOVERY AT FIRST HARVEST

Clone	*Number of Stems*	*Weight of Stems*	*Weight of Fibre*	*Fibre Recovery*
		lb.	lb.	Per cent.
K4.. ..	216	2,986	71	2.4
K6.. ..	36	651	13	2.0
K9.. ..	93	1,035	28	2.7
K22 ..	118	1,183	25	2.1
KT1 ..	131	1,952	50	2.6
KT6 ..	171	2,399	59	2.5
KT13 ..	91	1,274	36	2.9
KT14 ..	62	585	17	2.9
KT22 ..	90	1,290	26	2.0
KT25 ..	9	81	1.5	1.9
KT31 ..	192	2,603	65	2.5
KT32 ..	119	1,332	35	2.6
KT34 ..	153	2,026	52	2.6
KT35 ..	57	505	22	4.4
KT36 ..	76	1,049	24	2.3
KT37 ..	242	3,489	82	2.4
KT38 ..	204	2,553	57	2.2
KT39 ..	179	973	23	2.4
KT40 ..	125	1,791	42	2.3
KT42 ..	204	3,288	79	2.4
KT43 ..	179	2,496	63	2.5
KT44 ..	199	2,203	53	2.4
KT45 ..	209	2,409	66	2.7
KT46 ..	91	1,425	30	2.1
KT47 ..	134	1,769	41	2.3
Mean ..	131	1,734	42	2.4

KMT2. The Potential Commercial Value of a Clone

In fourteen harvests up to June 1962, this quarter-acre block yielded a total of 1,330 pseudostems weighing 67,570 lb. and producing 1,512 lb. of fibre. This represents a 2.24 per cent. recovery of fibre.

Details of yields in the twelfth to fourteenth harvests are shown in Table 77. There have been wide fluctuations in yield at different harvests, on a greater scale than could be explained by the variation between periods of harvesting. Possibly much of the explanation lies in varying efficiency of harvesters, as there have been frequent changes in the labourers employed on this task. The variations do not appear to follow a seasonal cycle.

TABLE 77. KMT2. FIBRE PRODUCTION FROM ¼ ACRE PLOT OF ABACA CLONE, KT8

YIELDS AT TWELFTH TO FOURTEENTH HARVESTS, 1961–62

Harvest No.	*Days Since Last Harvest*	*Weight of Stems*	*Weight of Fibre*	*Fibre Recovery*
		lb.	lb.	Per cent.
12	119	8,647	185	2.14
13	104	6,842	139	2.03
14	97	5,150	102	1.98

Harvests during 1962-63 were not yield recorded.

Breeding and Genetic Investigations

With decreasing emphasis on this crop, breeding work has been discontinued and the polyclonal seed garden was not planted.

Of the six Bangulanon seedlings received from North Borneo, one died and the five survivors did not show much promise in their early growth.

Fibre Recovery Variation

In trials over several years, considerable variability has been noted in fibre recoveries from the same clone at different times. A study was made of sources of variability in the processing in September 1961, by dividing all stems of three different clones into quarters, to make four equal groups, and processing these groups separately. Two groups were processed with one decorticator and two with another. The results indicated considerable variability between replicates and a slight, but fairly consistent, difference between machines. The trial showed that considerable variability is inherent in the processing method.

Another trial was made to study the influence of size of pseudostem on fibre recovery. Material used was 122 stems from KT8 in trial KMT2. Circumference of stems was measured at a point 6 feet from the top, and they were classed according to size with each size processed separately. Stem lengths as well as weights of stem and fibre were recorded. Results are shown in Table 78, and indicate that fibre recovery is higher from larger stems.

TABLE 78. STEM DIAMETER AND FIBRE RECOVERY IN MANILA HEMP

RESULTS OF TRIAL ON KT8, NOVEMBER 1961

Circumference	*Number of Stems*	*Average Length*	*Average Weight*	*Fibre Recovery*
in.		ft. in.	lb.	Per cent.
9	1	8 3	17	1.5
10	1	10 5	31	1.6
11	1	11 10	32	1.2
12	2	10 8	40	0.9
13	3	9 8	30	1.9
14	17	11 0	52	1.8
15	33	11 8	67	2.2
16	29	11 8	79	2.2
17	16	11 8	86	2.1
18	13	11 8	77	2.6
19	6	11 9	109	2.4

FOOD CROP AGRONOMY AND SOIL FERTILITY STUDIES

KSF2. Soil Exhaustion Trial

During the two years up to June 1963, the 13th to 16th plantings were used to eliminate residual effects of fertilizers applied in the 11th and 12th plantings. There was some indication of a residual effect of nitrogen treatments in the twelfth planting, causing a decline in yields of the nitrogen plots, but in later plantings this had disappeared. Yields of the plots which had received the higher rates of phosphorus were somewhat depressed in the fifteenth planting, but it is most unlikely that this was more than a chance effect.

Average yields for all plots, converted to pounds per acre were as follows—

10th planting	..	3,291 lb.
11th planting	..	4,016 lb.
12th planting	..	6,107 lb.
13th planting	..	8,694 lb.
14th planting	..	2,898 lb.
15th planting	..	4,046 lb.

The sixteenth planting was still growing at June 1963.

As reported in 1960-61, pot trials were commenced, using soil from the plots of the Soil Exhaustion Trial, to study the fertility status in more detail before a further field trial was undertaken.

NK Pot Trial: The original field trials did not include potassium as Keravat soils are generally very rich in this element and deficiency was considered unlikely. However, the high top growth response to nitrogen, without a corresponding response in tuber production, indicated that some other major element may be limiting. An alternative explanation may have been that the level of nitrogen applied had been inadequate, hence in the pot trial rates up to 800 lb. per acre nitrogen (four times the maximum in the field trial) were used.

Details of treatments were given in the 1960-61 Annual Report. The main responses were evident in the figures for weight of top growth of the sorghum test plants, shown in Table 79. Analysis showed the response to nitrogen to be significant at the 0.1 per cent. level, and it is obvious that the lowest level (200 lb. nitrogen per acre) was sufficient to rectify the deficiency. Potassium response was just significant at 5 per cent. when the K_0 yield was compared

with the average yield of all positive K levels. Again, the lowest level (½ cwt. per acre) was sufficient to correct the deficiency.

TABLE 79. KSF2. NK POT TRIAL

OVEN-DRY WEIGHT OF TOP GROWTH OF SORGHUM PLANTS

Treatment	*Weight*	*Treatment*	*Weight*
	gm.		gm.
K_0	102.6	N_0	72.1
K_1	119.7	N_1	128.1
K_2	113.5	N_2	124.9
K_4	118.0	N_4	128.7

Omission of Nutrients Pot Trial: Details of lay-out of this pot trial were given in the 1960-61 Annual Report. Results are shown in Table 80. Analysis showed the responses to N, P, Mg and minor elements to be significant, with K marginal.

TABLE 80. KSF2. OMISSION OF NUTRIENTS POT TRIAL

OVEN-DRY WEIGHT OF TOP GROWTH OF SORGHUM PLANTS

Treatment	*Number of Pots*	*Weight per Pot*
		gm.
Complete	11	18.08
Control	12	9.53
Complete minus N	5	12.40
Complete minus P	6	14.03
Complete minus K	6	16.23
Complete minus Ca	6	17.34
Complete minus Mg	6	11.35
Complete minus Minors	6	15.39
Complete minus S	12	18.24
	5 per cent.	1 per cent.
L.S.D. between means of 12,12 ..	2.33	3.10
12,6 ..	2.85	3.80
12,5 ..	3.04	4.04

Organic Matter Pot Trial: A trial with 102 large plastic pots was carried out to investigate the immediate and delayed effects of three kinds of organic matter on the exhausted soil. There were a total of sixteen treatments, although some were applied only at the second planting. Each was represented by six pots (except the control with twelve) containing six pre-germinated sorghum seedlings. Treatments and results are summarized in Table 81.

TABLE 81. KSF2. ORGANIC MATTER POT TRIAL

OVEN-DRY WEIGHTS OF SORGHUM TOP GROWTH

Treatments	*Average Weight per Pot (gm.)*	
	First Planting Second Harvest	*Second Planting Second Harvest*
1. Control	5.13	3.00
2. Chopped forest litter (C.F.L.) ..	7.35	4.19
3. C.F.L. + nitrogen	12.12	4.17
4. C.F.L. + fertilizer[1] (no nitrogen) ..	9.42	4.59
5. C.F.L. + fertilizer + nitrogen ..	19.47	3.62
6. Green manure[2] (G.M.)	10.86	4.90
7. G.M. + nitrogen	16.23	3.65
8. G.M. + fertilizer (no nitrogen) ..	22.09	4.07
9. G.M. + fertilizer + nitrogen ..	19.54	4.10
10. Compost[3]	..	4.56
11. Compost + nitrogen	..	5.45
12. Compost + fertilizer (no nitrogen) ..	..	5.11
13. Compost + fertilizer + nitrogen ..	..	3.26
14. Complete inorganic fertilizer ..	..	3.76
15. C.F.L. fallow first planting ..	..	3.45
16. G.M. fallow first planting ..	..	3.48

Notes:
[1] Fertilizer mixture containing P, K, Ca, Mg and Minors.
[2] Green manure consisted of chopped air-dried *Pueraria*.
[3] Chopped forest litter composted for three months.

The trial was carried over two plantings of sorghum and was harvested twice over each planting. In the first harvest, three random sorghum plants were harvested from each pot and the other three left till the second harvest. The treatments (10-14) added in the second planting were applied to soil which had been collected at the same time as the other and stored in a copra sack. Soil for treatments 15 and 16 was placed in pots and organic matter applied along with treatments at the first planting, but the pots were left fallow till the second planting. All fertilizers and organic matters were applied once only (i.e. 2-9,15, 16 at the first planting and 10-14 at the second planting). Pots were free drained.

Statistical analysis of the results showed that organic matter generally improved the soil but the effect was short lived. Green manure was more effective than forest litter, but neither provided sufficient nutrients for maximum growth. The very poor growth of all treatments at the second planting makes any interpretation difficult, and invalidates comparison between the two plantings.

TABLE 82. KSF2. MINOR ELEMENT POT TRIAL

Top Growth of Sorghum Plants

Element	Oven Dry Weights of Top Growth			Total Stem Length per Pot		
	Means—Element Present	Means—Element Absent	Difference	Means—Element Present	Means—Element Absent	Difference
	gm.	gm.	gm.	in.	in.	in.
Cu	2.320	2.064	0.256	32.37	29.38	2.99
Zn	1.868	2.517	−0.649**	27.38	34.38	−7.00
Mn	2.418	1.966	0.452*	33.31	28.44	4.87
Fe	2.153	2.232	−0.079	30.69	31.06	−0.37
B	2.151	2.233	−0.082	30.75	31.00	−0.25
Mo	2.218	2.167	0.051	32.00	29.75	2.25
Least Mean Difference for significance: 5 per cent.			0.424	..	..	9.68
1 per cent.			0.574	..	..	13.11

Minor Element Pot Trial: This trial was carried out in 32 pots, using a soil sample collected from the eight plots which received no minor element applications in the 11th and 12th plantings. The trial was designed as a half replicate of 2^6 factorial, to study copper, zinc, manganese, iron, boron and molybdenum. Basal dressings of N, P, K, Ca, Mg and S were applied to each pot. Fertilizers were applied in solution at the commencement of the trial.

Sorghum was used as the test plant, three plants per pot. The pots were harvested seven weeks after planting, and stem lengths and oven-dry top growth weights were recorded. The results are summarized in Table 82.

Manganese deficiency was significant, while zinc depressed yields, as measured by weights of top growth.

Major and Minor Element Pot Trial: This trial aimed to test rates of nitrogen and phosphorus required and to further study responses to magnesium and calcium and minor elements. Four replicates were used of thirteen treatments, consisting of twelve treatments comprising a half replicate of factorial combinations of N at 3 positive levels, P at 2 positive levels, MgCa grouped and mixed minor elements (X) at zero and one positive level, with a basal dressing of potassium, and a nil fertilizer control. Rates of each element expressed as parts per million in the soil were K = 30, N_1 = 50, P_1 = 100, Mg = 10 and Ca = 50. There were six sorghum plants per pot and fertilizers were applied in solution in three split applications.

Analysis of the results expressed as total plant dry weight showed a clear increase of the fertilized treatments over the control, which could be due to the minimal dressing of K N_1 P_1. However, the differences between levels of N, P, MgCa and X were not statistically significant although the average responses to P, MgCa, and X were all positive. The apparent nitrogen effect was confusing, with N_2 less than N_1 but N_4 greater than N_1.

Copper, Manganese, Zinc Pot Trial: To confirm the results of the minor element trial described above, a further trial was carried out with the three elements which had appeared to have an effect. The trial was a 2^3 factorial with an additional treatment containing all minor elements, all with a basal dressing of major elements. Soil was taken from the "nil" treatment plots of the Soil Exhaustion Trial. Each treatment was replicated three times on pots containing six sorghum plants each. Fertilizer was applied in solution in three equal split applications. Results are shown in Table 83.

TABLE 83. KSF2. COPPER, MANGANESE, ZINC POT TRIAL

Oven-dry Weights of Sorghum Plants

Treatment	Average Weight per Pot	
	Element Absent	Element Present
	gm.	gm.
Cu	5.83	6.24
Mn	5.15	6.92
Zn	5.97	6.10

Statistical analysis showed the effect of manganese to be significant at the 0.1 per cent. level. There was no indication of any requirement for other minor elements.

Potassium Rates Pot Trial: The trial was carried out in 9 inch plastic pots, using soil taken from all 64 plots of the Soil Exhaustion Trial. This was valid since no potash had been applied in the 11th and 12th plantings of the trial. The pot trial consisted of five treatments, each with three replications. Six sorghum plants were grown in each pot as the test crop.

Treatments were—

K_0 = 0 p.p.m. K in soil
K_1 = 15 p.p.m. K in soil
K_2 = 30 p.p.m. K in soil
K_4 = 60 p.p.m. K in soil
K_8 = 120 p.p.m. K in soil

A basal dressing of N, P, Ca, Mg, S and minor elements was applied to all pots. Fertilizer applications were made in solution in three equal split applications.

Results are shown in Table 84, and indicate a potassium deficiency corrected by the lowest rate of application (15 p.p.m. in soil). This corroborates the evidence of the NK and Omission of Nutrients Pot Trials.

TABLE 84. KSF2. POTASSIUM RATES POT TRIAL

OVEN-DRY WEIGHT OF SORGHUM PLANTS

Treatment	*Average Weight per Pot*
	gm.
K_0 ..	3.96
K_1 ..	5.38
K_2 ..	5.20
K_4 ..	5.37
K_8 ..	5.47

Magnesium Rates Pot Trial: This was run concurrently with the Potassium Rates Pot Trial, using similar materials and methods. The rates used were one third of those for potassium (i.e. $Mg_1 = 5$ parts per million). The basal dressing contained N, P, K, Ca, S and minor elements. Analysis of results shown in Table 85 indicated no response to magnesium at any level. However, during the course of the trial, plants had been sprayed with the insecticide " Sevin " and it was subsequently learned that this preparation may have contained a magnesium compound in the carrier. This could have invalidated the comparison.

TABLE 85. KSF2. MAGNESIUM RATES POT TRIAL

OVEN-DRY WEIGHTS OF SORGHUM PLANTS

Treatment	*Average Weight per Pot*
	gm.
Mg_0 ..	6.21
Mg_1 ..	5.02
Mg_2 ..	4.84
Mg_4 ..	5.48
Mg_8 ..	5.21

Future Pot Trials: Further trials will be carried out using sweet potato as test plant instead of sorghum. A series of five trials is planned to check and confirm the findings with the indicator plant. Subsequently, trials will be made again in the field.

Soil Exhaustion Block B: The area of the original soil exhaustion trial is only small and this limits the work that can be done in efforts at rejuvenation of the soil. To provide a bank of exhausted soil, a plot 4 chains square in Block 208 was planted to sweet potato (variety K1) in 1962 with the aim of continuous cropping to the state of exhaustion. The plot had been used intermittently for food crop gardening in the past so should already have been somewhat depleted.

The first harvest yielded at 4.9 tons per acre and a second yielded at 2.3 tons per acre. The rows of each crop were planted at right angles to those of the previous crop, and yield was recorded by rows, so as to gain some index of fertility gradients over the plot. At June, 1963, a third crop was growing, but weeds were proving a serious problem.

KSF1. Three Course Rotation Trial—Block 608

The trial is now in the fourth planting of the third cycle. In the first planting of the cycle, the 21 sweet potato plots in Series A were used for Sweet Potato Maturity Trial 1, with row by row harvesting over a ten-week period. The earliest rows harvested were not fully mature, so for the purpose of the Rotation Trial plot yields were estimated by doubling the yields from the last half of the rows harvested. The plots of the third planting of Series B were used in a similar way for Sweet Potato Maturity Trial 3, with similar adjustments made to yield records.

At the end of the second cycle, *Phaseolus calcaratus* was deleted from the trial because of severe nematode damage suffered by it. Its place was taken by *Indigofera endecaphylla* in the first planting of the third cycle. However, this species proved too slow in establishment, and from the second planting cowpea (*Vigna* sp.) is being used instead, with satisfactory growth.

Mean yields for the three replicates of each treatment in the three series are shown in Table 86 for all plantings yet harvested. No yields were recorded for some plantings of peanuts and taro which were devastated by diseases.

TABLE 86. KSF1. THREE COURSE ROTATION TRIAL

CROPS PLANTED, AND MEAN YIELDS ('00 LB. PER ACRE) OF CROPS HARVESTED

Cycle	*Planting*	*Rotation 1 Crop and Yield*	*Rotation 2 Crop and Yield*	*Rotation 3 Crop and Yield*	*Rotation 4 Crop and Yield*	*Rotation 5 Crop and Yield*	*Rotation 6 Crop and Yield*	*Rotation 7 Crop and Yield*
Series A—								
1.. ..	1	SP–180	SP–194	SP–185	SP–230	SP–197	SP–183	SP–186
	2	To–69	So–15	To–51	To–46	To–55	To–52	So–16
	3	P–	P–	Ph	P–	P–	P–	P–
	4	M	M	SP–36	SP–38	SP–30	Pu	Pu
	5	M	M	To–58	To–58	To–56	Pu	Pu
	6	M	M	Ph	P–9	P–8	Pu	Pu
2.. ..	1	SP–127	SP–135	SP–145	SP–153	SP–142	SP–157	SP–151
	2	To–44	So–47	To–26	To–33	To–34	To–40	So–45
	3	P–26	P–36	Ph	P–26	P–29	P–28	P–27
	4	M	M	SP–49	SP -72	SP–64	Pu	Pu
	5	M	M	To–21	To–28	To–33	Pu	Pu
	6	M	M	Ph	P–26	P–23	Pu	Pu
3.. ..	1	SP–82	SP–72	SP–45	SP–51	SP–70	SP–60	SP–67
	2	To–20	So–10	To–14	To–18	To–19	To–22	So–10
	3	P–26	P–30	CP	P–25	P–26	P–26	P–24
Series B—								
1.. ..	1	M	M	To–57	To–57	To–55	Pu	Pu
	2	M	M	Ph	P–	P–	Pu	Pu
	3	SP–249	SP–241	SP–257	SP–249	SP–215	SP–271	SP–312
	4	To–68	So–23	To–63	To–69	To–63	To–84	So–28
	5	P–21	P–24	Ph	P–22	P–20	P–20	P–21
	6	M	M	SP–108	SP–156	SP–141	Pu	Pu
2.. ..	1	M	M	To–41	To–50	To–54	Pu	Pu
	2	M	M	Ph	P–26	P–25	Pu	Pu
	3	SP–164	SP–150	SP–134	SP–96	SP–98	SP–199	SP–199
	4	To–53	So–27	To–36	To–27	To–24	To–41	So–29
	5	P–26	P–26	Ph	P–25	P–27	P–28	P–34
	6	M	M	SP–68	SP–63	SP–45	Pu	Pu
3.. ..	1	M	M	To–18	To–10	To–10	Pu	Pu
	2	M	M	CP	P–19	P–19	Pu	Pu
	3	SP–86	SP–72	SP–51	SP–17	SP–11	SP–129	SP–131
Series C—								
1.. ..	1	P–38	P–38	Ph	P–41	P–37	P–43	P–37
	2	M	M	SP–53	SP–65	SP–76	Pu	Pu
	3	M	M	To–	To–	To–	Pu	Pu
	4	M	M	Ph	P–23	P–20	Pu	Pu
	5	SP–174	SP–164	SP–158	SP–137	SP–166	SP–148	SP–148
	6	To–	So–10	To–	To–	To–	To–	So–12
2.. ..	1	P–31	P–32	Ph	P–27	P–28	P–30	P–27
	2	M	M	SP–124	SP–135	SP–145	Pu	Pu
	3	M	M	To–25	To–36	To–35	Pu	Pu
	4	M	M	Ph	P–18	P–18	Pu	Pu
	5	SP–113	SP–144	SP–146	SP–76	SP–101	SP–162	SP–173
	6	To–18	So–21	To–13	To–16	To–18	To–15	So–17
3.. ..	1	P–33	P–37	Ind.	P–36	P–34	P–32	P–33
	2	M	M	SP–57	SP–68	SP–67	Pu	Pu
	3	M	M	To–19	To–11	To–8	Pu	Pu

SP = sweet potato
To = taro
P = peanut
So = sorghum
M = *Mimosa invisa*

Ph = *Phaseolus calcaratus*
CP = cowpea
Pu = *Pueraria*
Ind. = *Indigofera endecaphylla*

KSF3. Effect of Soil Deterioration on Sweet Potato Maturity

Observation of the sweet potato plants in the Soil Exhaustion Trial as it progressed had led to a suggestion that the crop matured earlier as soil fertility deteriorated. Three trials were carried out to study this more closely and also to determine more accurately when the crop was at the best stage for harvesting. The basic technique used in the three trials was row by row harvesting with a time lapse between harvesting each row. Plot size was 30 ft. square.

The first two trials have been finalized but results of the third trial have not yet been drawn together.

Sweet Potato Maturity Trial 1: This trial was superimposed on the 21 plots of Series A, 1st Planting, 3rd cycle of the Three Course Rotation Trial, when all plots were under sweet potato. It was hoped that differences in time to sweet potato maturity would be evident between wide and narrow rotations.

There were ten rows of sweet potato in each plot. These were harvested consecutively across the plots at weekly intervals, beginning when the crop was approximately six months old, and continuing for ten harvests. The following details were recorded—

1. Weight of tubers from each row.
2. Number of tubers from each row.
3. Number of rotted tubers from each row.
4. Number of flowers from each row harvested.
5. The colour of the dried sap from the cut tuber.
6. Whether this sap beaded or ran when the tuber was cut.
7. The vigour of the crop on each plot.

Analysis of the results showed—

1. No difference in time trend between the yield increases of wide and narrow rotations, although there was a significant difference between total yields.

2. Tuber size reached a maximum during the period of the trial, and wide rotations produced larger tubers than narrow rotations. There was no difference in the rate of increase in tuber size between wide and narrow rotations during the period of the trial.

3. The slight increase in the number of tubers during the trial was not significant.

4. Flowering came to a peak at about the time that yields reached a maximum, but there was no time difference in flowering between wide and narrow rotations.

5. There was a large positive edge effect in plot yields (i.e. outside lines gave highest yields).

Sweet Potato Maturity Trial 2: It became clear during the running of the first maturity trial that knowledge of what comprised a "mature" sweet potato crop was lacking, and to seek this information, a nine plot trial was set down on virgin soil to investigate the crop further.

Essentially the same techniques were used and observations made as in the first maturity trial. However, as a measure of tuber maturity, tubers were boiled and tasted, and assessments of palatability were made. Harvesting began at three months and continued at fortnightly intervals for ten harvests.

The trial failed in its objective of relating maximum yield to some readily visible factor such as crop vigour or flowering. Flowering was probably still increasing at the time of the last harvest and yield also was increasing, although the rate of increase slowed down after about the fifth harvest. Rotting of tubers had not reached a significant level at the close of the trial. Tuber maturity, as assessed by flavour or by beading of the sap, certainly came earlier than maximum yield.

Minor Soil Fertility Investigations

As a guide for fertilizer recommendations requested by local plantations, simple pot tests were carried out on five soil samples. These trials involved tests for N, P, K, Ca, Mg and minor element deficiencies, using the omission method. Future tests will include sulphur also. Encouraging reports were received of good results following recommendations based on the first two tests.

Sunflower (Helianthus annuus)

A variety of sunflower received from Aiyura was planted in a plot of one quarter acre late in 1961. The plot had been covered with *Pueraria phaseoloides* for several years.

Sunflower was planted by seed in rows three feet apart, and thinned to eight inches in the row. The crop was harvested eleven weeks after planting and yielded at the rate of 632 lb. seed per acre.

The same plot was replanted with sunflower at the same spacing. After 13½ weeks the crop was harvested, and yielded at the rate of 404 lb. seed per acre.

It was noted that a high proportion of the seed harvested in both of these plantings was empty. It is possible that there was poor pollination owing to lack of efficient insect pollinators.

The nematode *Meloidogyne javanica* was collected and identified from the roots of sunflower grown on the above quarter acre plot.

Variety Trial: Six varieties of sunflower were tested, two plots of each variety, in randomized plots. Each plot was 30 feet square, with spacing as above. Varieties tested and yields are shown in Table 87.

TABLE 87. SUNFLOWER VARIETY TRIAL

YIELDS CONVERTED TO POUNDS SEED PER ACRE

Variety	*Yield*
Californian White ..	944
Jupiter	145
? (Kapogere) ..	0
? (Aiyura).. ..	726
Polestar	0
NG5514	992

Polestar and the variety from Kapogere did not survive in the plots.

Variety x Spacing Trial: The three varieties which proved successful in the variety trial were planted at three spacings (1 ft. x 1 ft., 2 ft. x 1 ft. and 3 ft. x 1 ft.) in a new trial. Establishment was very uneven, with the result that spacings did not even approximate to the desired levels and general variability prevented a valid comparison between varieties.

Rice (Oryza sativa)

Three 30 ft. square plots of rice were planted in December 1962 for observation. Seed was drilled in rows 3 ft. 6 in. apart. The dry-rice system of cultivation was used, as it is unlikely that the flooded system would be satisfactory at Keravat, because of the permeable nature of the soil.

By mid April 1963, the crop stood about 6 ft. high and the grain was at the milky stage. This was a very wet period and the whole crop lodged. No yield data were recorded but grain was collected for future seed supplies.

The crop was allowed to ratoon and reached a height of 30 to 36 inches, but did not yield as heavily as the plant crop. The ratoon crop did not lodge.

MISCELLANEOUS

SHADE TREES

Leucaena Varieties

A number of strains of *Leucaena glauca* and *L. glauca* x *L. pulverulenta* hybrids were planted for observation and comparison with the local strain of *L. glauca.*

Plate 13. Growth of *Leucaena glauca (leucocephala)* strains at Keravat. Peru at left, local at right. (*Photo: A. E. Charles*)

Strains of *L. glauca* from Peru, El Salvador and Guatemala were sown with local strain in a nursery in October 1959 and transplanted in January 1961. Measurement in June 1961 showed average height of local strain as 7.4 ft., Peru 8.5 ft., El Salvador 9 ft., Guatemala 11 ft. The introduced strains retained their height advantage in further growth, seeded less freely than local and had darker green leaves. (See Plate 13). Although the Guatemala strain was taller than Peru or El Salvador, the last two were more bushy in habit and would provide similar shade. The Guatemala strain has been multiplied for seed distribution.

In January 1961, seed of several strains of *L. glauca* x *L. pulverulenta* crosses were planted in a nursery. Germination was variable and comparison of growth was unreliable. In February 1962 the seedlings were transplanted in comparison plots with local strain, but dry weather after transplanting resulted in many deaths. In October 1962 comparison indicated that most of the hybrids were more vigorous than the local strain, but ranking was uncertain.

In February 1962 seed of some of these hybrids was planted together with the local and introduced *L. glauca* for further comparison. Again early growth was uneven, and in an assessment of vigour made in October 1962 distinctions were very doubtful. It appeared probable that the *L. glauca* introductions were more vigorous than the hybrids. However, at the time of transplanting in June 1963 it was found impossible to distinguish varieties on vigour with any confidence at all.

Temporary Shade Species

In planting cacao and coffee in this country it has frequently been the practice to plant quicker growing leguminous species with the *Leucaena glauca* permanent shade. These temporary shade species, such as *Crotalaria anagyroides*, last for only a year or two but, by quicker earlier growth, permit planting of the cacao at a time when the local leucaena would not yet give adequate shade.

An observation plot was planted in May 1962, to compare the performance of *Flemingia congesta*, a vigorous, erect, leafy leguminous shrub, and the Guatemalan strain of leucaena, which is more vigorous than the local strain, with the standard *Crotalaria anagyroides*. Seed was sown in rows four feet apart, arranged thus:

L-C-F-C-L-C-F-C-L-C-F

(L = Guatemalan leucaena; C = *Crotalaria anagyroides;* F = *Flemingia congesta*).

Crotalaria seed germinated first, but all species had germinated by the end of the second week. After some months the leucaena proved superior to the other two species, both in spread and height. One year after planting the average heights of each species were:

Guatemalan leucaena	22 feet
Crotalaria anagyroides	12 feet
Flemingia congesta	11 feet

The leucaena grew into tall plants with the main stem bare of laterals, but with a good spread in the canopy. Most plants were shy seeding, although a few carried large numbers of pods. There was no sign of volunteer seedling growth.

At twelve months, the *Crotalaria* had lost its vigour and plants were dying and seeding profusely. Death may have been hastened through overshading by the leucaena.

Vigour of the *Flemingia* remained good and there was considerable leaf mulch on the soil. Seed production was copious, but there was little volunteer seedling growth.

The trial indicated that, on the fertile volcanic ash soils at least, use of the vigorous Guatemalan strain of leucaena could eliminate the need for temporary shade. The trial will be repeated in larger plots to avoid growth of one species influencing that of others.

HERBICIDE OBSERVATIONS

A number of tests were made on herbicide samples provided by I.C.I., Geigy and Shell.

Black Polythene

A mulch of black polythene sheeting may be placed around the base of seedlings to prevent weed growth and conserve moisture. Observations were made on the effectiveness of 36 in. square sheets around young cacao seedlings. It was noted that these had to be weighted down carefully so that the sheet could not blow over the seedling. The sheets tended to be overgrown by creeping grasses, which eventually even took root in the leaf litter and dust accumulating on the surface. Thus the need for hand weeding in the early stages, although probably simplified, was not eliminated. Any beneficial effect as a mulch was not tested.

Diesel Oil

It is common practice in orchards in the U.K. to spray around the bases of trees with diesel oil for weed control, the base of the tree being shielded during spraying. This method was tested around young seedling cacao. It was found that weed kill

was complete only if the foliage was very thoroughly wetted, and that regrowth commenced within two months of spraying. Diesel oil is probably no more effective than 1/400 "Diquat" and much more expensive.

Triazines

Simazine showed promise for weed control in coconut nurseries. Tests showed that simazine at 2 lb. a.i. per acre applied to bare soil gave satisfactory weed suppression for about three months. Propazine at the same rate was not effective. No damage to coconut seedlings was evident, even with much higher concentrations of simazine. However, simazine was not at all effective in controlling *Imperata,* so that it would be of little value for weed control around coconuts in the field.

Preliminary toxicity tests indicated that high concentrations of triazines could kill cacao seedlings, although some survived with probable retardation of growth and a characteristic heavy chlorosis of those leaves which had been developing at the time of spraying.

In a field test with simazine at 2 lb. a.i. per acre as a pre-emergence spray, no damage was evident to cacao seedlings and weeds were suppressed for 3-4 months. This test was made under fairly heavy *Leucaena* shade, where in any case weed growth was light. In another field test, the same concentration of simazine was sprayed around young cacao seedlings growing under only light shade. Weed growth was heavy and clean weeding was necessary before spraying. The spray gave fairly good weed control, but after about three weeks symptoms of toxicity showed on several cacao seedlings. None was killed, but growth was probably retarded. Consequently simazine could not be recommended for young cacao seedlings.

Prometryne, which is recommended for pre-emergence use with legumes, at 4 lb. a.i. per acre killed germinating *Leucaena* and *Pueraria* seedlings. It has not yet been tried at lower concentrations.

Atrazine, which is a more soluble type, when sprayed shortly before rain fell had virtually no noticeable effect on weeds. It is probable that the less soluble triazines are to be preferred for these high-rainfall conditions.

Gramevin

Gramevin at 90gm/gallon gave good suppression of heavy grass growth in a stand of young *Leucaena,* where weed competition was retarding *Leucaena* growth. Grass was suppressed, though not completely killed, for more than two months, but after some weeks it was noticed that the *Leucaena* was also damaged. New leaves were malformed and growth retarded, so that the purpose of weed control was defeated. The plants affected were 4 to 6 feet tall.

In a toxicity test with coconut seedlings it was found that direct contact caused some burning of the fronds, and also after several weeks it was evident that the newly emerging leaf was retarded and reduced in size, even where direct spraying of the foliage had been avoided.

Dalapon

Dalapon at the rate of 10 lb. per acre in 80 gals water gave almost complete kill of heavy matted couch grass. At 5 lb. per acre the kill was estimated at about 75 per cent.

Diquat and Paraquat

These are plant desiccants which have a very rapid contact effect on foliage, but are quickly broken down on contact with the soil.

Sprayed on grassy weed growth in young leucaena lines (as described for gramevin), at a concentration of 1:400, good weed kill was produced, but within four to five weeks weeds had reinvaded the area. Contact with the leucaena stems caused no apparent harm. Contact with leaves caused the leaflets to shed within a day or two, but with reasonable care in spraying the plants should suffer no appreciable harm.

Diquat caused contact necrosis on cacao leaves. Spraying weeds around young seedlings did not cause much damage when done with care, but shielding of the seedlings would probably be desirable. Use of 1:400 dilution on weed growth 12-18 inches high gave good weed control for up to six weeks, and cost of ring-weeding in this way was approximately 0.3d. per seedling (materials only). Repetition of the treatment would probably cost less as weed growth would be less vigourous.

Diquat at 1:400 dilution gave fairly good kill of *Passiflora foetida,* a vigorous creeper which is very common on newly cleared land. All the outer runners were killed, but the bases of the plants sent out new shoots within a week or two, and follow-up treatment would be necessary.

Similar results were obtained with paraquat.

In all tests the dilution factor refers to dilution of commercial product containing 40 per cent. active ingredient, and a non-ionic wetting agent was used. To be effective, foliage had to be thoroughly wetted with the spray.

2,4-D.

Shell "Weedkiller D" (50 per cent. 2,4-D amine) was tested for control of *Passiflora foetida.* At a dilution of 1:200 it gave similar results to diquat. Complete wetting of the foliage was necessary, and the effect was not systemic, bases of the plants shooting again. Higher concentration, though causing rather quicker defoliation, did not give any better results in the long run.

Leucaena glauca *Poisoning Trial*

In October 1962, a trial was laid down to compare the efficiency of 2,4,5-T and 2,4-D, both separately and in combination, in killing the shade tree *Leucaena glauca.* The materials used were a commercial preparation containing 30 per cent. W/V of 2,4,5-trichlorophenoxyacetic acid as the monobutyl glycol ester, and a commercial preparation containing 80 per cent. of 2,4-dichloro phenox y acetic acid as ester. Diesel distillate was used as diluent and tested alone as a control treatment.

Details of the trial are given below:

Treatments. (a) 4 parts 2,4,5-T .. 0 parts 2,4-D
(b) 3 parts 2,4,5-T .. 1 part 2,4-D
(c) 2 parts 2,4,5-T .. 2 parts 2,4-D
(d) 1 part 2,4,5-T .. 3 parts 2,4-D
(e) 0 parts 2,4,5-T .. 4 parts 2,4-D
(f) Control

Each mixture was added to diesoline in the ratio 1:80, while the control treatment (f) was diesoline alone.

Sub-Plots: Sub-plots were used to determine whether slashing the tree with a knife prior to the application of the herbicide enabled the chemical to be more efficient in killing the trees. These sub-plots were designated:

S—Trees slashed
N—Trees not slashed

Sub-Sub-Plots: In each sub-plot there were ten trees. One worker applied herbicide to five of these, while another worker applied the chemical to the other five. Each tree was considered as a separate sub-sub-plot, so that the efficiency of the two workers might be compared, and so as to detect any effect that the order in which trees were poisoned had on the efficiency of each herbicide.

Application: The herbicides were applied with 3-in. paint brushes to 8-in. bands encircling the *Leucaena* trees, as close to the ground as possible. An average of 35 ml. per tree was used, so that, on the average, the quantity of active ingredient applied to each tree was as shown in Table 88.

TABLE 88. LEUCAENA POISONING TRIAL
QUANTITIES OF 2,4,5–T AND 2,4–D APPLIED PER TREE

Treatment	*2,4,5–T (mgm. active ingredient)*	*2,4–D (mgm. active ingredient)*
a ..	131.2	0
b ..	97.5	87.5
c ..	65.6	175.0
d ..	32.5	262.5
e ..	0	350.0
f ..	0	0

Observations: The time to defoliation was taken as being synonymous with the time to the death of the tree. A daily check of all trees was therefore made, and any trees which had defoliated during the previous 24 hours were recorded. The circumferences of all trees in the experiment were measured to determine whether the size of the tree affected the number of days to defoliation.

Results obtained to date suggest that 2,4,5-T alone (treatment a) caused defoliation to occur much sooner than any other treatment. The diesoline treatment has killed a number of trees and it will be interesting to see whether a 100 per cent. kill is obtained with this oil alone.

Oil Palm Poisoning Trial

In March 1963, a trial was laid down in Block 202 to determine the minimum volume of the herbicide "Diquat" required to kill 30-year old oil palms. This herbicide has been suggested as an alternative to sodium arsenite which is dangerous because of its high toxicity. A further aim was to investigate a suggestion that palms poisoned with diquat may not breed dynastid beetles.

Treatments were 5, 10, 15, 30, 50 and 70 ml. diquat per tree. There were three replications, making 18 palms in all in the trial. The herbicide was applied by pouring it into 3-4 in. cuts made with axes.

Palms which had been treated with 70 mls. of diquat were dead by June 1963. All other palms in the trial had apparently not been affected, but observations will be continued.

Cacao Poisoning Trial

In August to October 1961, tests were made on poisoning 12-year old cacao trees in a block which was being cleared for planting new coffee trials. A

commercial preparation of 2,4,5-T containing 30% active ingredient was tested at three concentrations with diesel oil as diluent (1:40, 1:80 and 1:120). Each concentration was tested by painting on to the trunks with and without prior frilling or slashing.

Two weeks after application no effect was visible and the same treatments were reapplied. A new treatment of 1:20 concentration, with and without slashing, was also tried. No visible effect could be detected up to eight weeks later.

The trial was then repeated with a fresh stock of 2,4,5-T. The only effect visible during the next six weeks was yellowing and death of leaves on a few young replants treated with 1:40 or 1:20 mixture.

HIGHLANDS AGRICULTURAL EXPERIMENT STATION, AIYURA

The H.A.E.S., Aiyura, is the major high-altitude experiment station in Papua-New Guinea, and is located near Kainantu in the Eastern Highlands District. A description and plan of the station were given in the 1959-60 Annual Report. Rainfall and sunshine data are shown in Appendix IV of this report.

COFFEE

COFFEE BREEDING

ACA5. First Series Progeny Trial (Block E6)

This trial, planted in 1957, compares 36 Blue Mountain, 4 San Ramon, 1 Maragogipe, 4 Arusha, 2 Mocha and 1 Harar selections with two controls which were taken from random unselected Blue Mountain bushes. The comparison was made in four sets—self-pollinated seedlings, open-pollinated seedlings, cuttings and grafts. The seedlings of both types were planted in alternating rows in a randomised block trial with four replicates; cuttings and grafts were planted in separate areas in randomised blocks with four replicates. The grafts, however, failed to become established and were abandoned.

The blocks proved highly variable, and this probably contributed to the very substantial yield differences obtained between progenies and between clones. However, differences between selections were significant statistically, and some were significantly better than the controls. Yields of self-pollinated and open-pollinated progenies of the same selections showed a good correlation, but there was no correlation between these and yields of cuttings. Up till March 1962, yields of all varieties fell within much the same range, but in 1962-63 the Arusha selections stood out, all four being better than any other selection.

ACA10. Second Series Progeny Trial (*Block E6*)

This comprises 3 randomized block trials each of 4 replicates of plots of 9 trees (3 x 3) of open-pollinated seedling progeny of 8 selections. One selection is common to all 3 groups. The selections include 8 Bourbon, 4 Blue Mountain, 4 Arusha, 2 San Ramon, 2 Mocha, 2 Harar and 1 Kents. The seed was sown in November 1957 and seedlings transplanted in February 1959. Spacing is 9 ft. square, with no guarding between plots.

Analysis of yields up to March 1962, showed substantial and highly significant differences between progenies, both within and between varieties. In the much heavier yields in 1962-63, differences were of a lower order. In 1961-62 Arusha and San Ramon selections were best, but in 1962-63 neither of these showed up very well and Mocha was outstanding.

ACA13. East African Introductions (*Blocks A6, E5, D5*)

Several varieties were introduced from East Africa in 1958 and planted out in March 1959, in a small scale randomized block trial. Plots are of 25 trees (5 x 5) planted at 8 feet square spacing, without guards. There are three replicates in Station block D5, but they are not in a compact area; a fourth replicate is in block A6 on a different soil type.

Some of these varieties look extremely vigorous and healthy. The first substantial yields were obtained in 1962-63, and several varieties outyielded the standard Blue Mountain. Yields of the replicate in A6 were much lower than in D5 and the ranking was different, but it is doubtful at this stage whether this can be taken as significant. Results are shown in Table 89.

TABLE 89. ACA13. EAST AFRICAN COFFEE INTRODUCTIONS

YIELDS 1962-63, CONVERTED TO POUNDS CHERRY COFFEE PER ACRE

Variety	*Average of Three Replicates in D5*	*One Replicate in A6*	*Average all Replicates*
SL28	9,384	3,632	7,945
SL14	9,057	4,130	7,824
KE20	8,730	2,755	7,235
Bourbon ..	8,685	2,747	7,199
SL34	7,967	2,039	6,485
Kents	7,432	3,063	6,337
Blue Mountain ..	6,470	2,284	5,428
Dalle Mixed Green	5,581	4,062	5,205
Least Significant Difference 5% ..	2,113	..	1,832

*ACA*1. *Shade Species x Spacing x Pruning Trial* (*Blocks B*15-16, *C*6, *D*6)

Some important variations in treatments were made in late 1961. Because of their failure to grow well, the silky oak shade trees were cut out. To utilize the area, which then became a second no shade treatment, combinations of fertilizing and mulching were applied orthogonally over the spacing and pruing treatments. Details are given under ACA29, but it should be noted here that yields of "silky oak" treatment are no longer strictly comparable with the other shade treatments.

At the same period, all except the former silky oak plots were given a fertilizer dressing of 3 cwt. NPK (12:12:19) plus 82 lb. urea per acre. This followed evidence, in other trials, of fertiliser response, and dieback symptoms in the ACA1 plots. In December 1962, and May 1963, further applications, at 112 lb. potassium sulphate and 56 lb. urea per acre, were made.

Average yields, showing treatment main effects, are given in Table 90.

Statistical analysis confirmed the apparent differences between treatments as significant—

(i) Higher yield on pit-pit soil up to 1961-62, with a reversal of trend in 1962-63. Causes of this are not clear, and it will be of interest to see yields in future years.

(ii) Highest yield in the absence of shade, with variation in merit of the shade species at the two sites.

(iii) Yield increasing at closer spacings in the early years, but with a levelling or reversal of trend by 1962-63.

(iv) Higher yield from single than multiple stem pruning, especially on the hillside soil. This locational effect may still result from the greater severity of multiple stem pruning on the hillside blocks in the early stages. It is thought that modifications within the two systems may be more important than the difference between single and multiple stem.

(v) Low yield of the former silky oak plots on the pit-pit soil. This may be partially explained by the lack of fertilizing (all other plots have received fertilizer since 1961), but the decline relative to the no shade plots began in 1960-61, probably before the fertilizer would have had any influence.

An important aspect that will be given more attention in future is the quality of coffee from the different shade treatments. There is some evidence that absence of shade leads to sun-burn of the berries and inferior quality.

TABLE 90. COFFEE SHADE-SPACING-PRUNING TRIAL, AIYURA

YIELDS (LB. CHERRY COFFEE PER ACRE) 1958–1963

Treatments	*1958–59*		*1959–60*		*1960–61*		*1961–62*		*1962–63*		*1958–63 Total*	
	A	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*
Shade—												
Casuarina ..	1,022	**317**	9,578	**4,943**	9,405	**9,087**	16,632	**6,979**	10,628	**16,366**	47,271	**37,696**
Albizia ..	920	**410**	9,459	**5,382**	9,606	**9,093**	15,895	**8,634**	7,645	**16,098**	43,531	**39,611**
Silky Oak* ..	955	**238**	10,577	**5,628**	9,601	**11,819**	13,426	**13,143**	7,090	**20,319**	41,656	**51,152**
No shade ..	445	**520**	10,719	**6,536**	13,554	**9,308**	26,296	**15,830**	14,019	**20,908**	65,043	**53,105**
Spacing—												
7 x 7 ..	973	**433**	12,283	**6,138**	13,003	**11,901**	20,051	**13,689**	9,217	**19,327**	55,601	**51,539**
8 x 8 ..	822	**410**	10,265	**6,181**	10,537	**9,697**	18,656	**10,888**	10,255	**19,568**	50,553	**46,786**
9 x 9 ..	709	**273**	7,657	**4,523**	8,069	**7,839**	15,456	**8,813**	10,066	**16,367**	41,970	**37,848**
Pruning—												
Single Stem	1,515	**742**	10,123	**6,222**	8,945	**11,032**	18,521	**12,167**	10,297	**20,445**	49,463	**50,657**
Multiple Stem	153	**0**	10,015	**5,006**	12,108	**8,593**	17,551	**10,092**	9,395	**16,396**	49,286	**40,125**
General Mean	834	**371**	10,069	**5,614**	10,527	**9,812**	18,062	**11,120**	9,846	**18,421**	49,375	**45,391**

A: replicates I-IV on pit-pit soil. B: replicates V-VIII on hillside soil. * Silky oak grew poorly and was cut out in August 1961.

TABLE 91. ACA2. COFFEE VARIETY x SPACING TRIAL

YIELDS (LB. CHERRY COFFEE PER ACRE) 1958–1963

Variety	1958–59		1959–60		1960–61		1961–62		1962–63		1958–63 Total		
	9 ft.	7½ ft.	9 ft.	7½ ft.	9 ft.	7½ ft.	9 ft.	7½ ft.	9 ft.	7½ ft.	9 ft.	7½ ft.	Mean
Blue Mountain ..	969	1,586	5,592	9,428	6,294	7,848	15,118	16,946	6,347	4,895	34,320	40,703	37,512
Arusha ..	1,176	1,157	10,414	9,216	9,650	11,095	18,232	12,425	8,824	5,158	48,306	39,051	43,679
Mocha ..	1,102	1,350	13,291	12,002	9,504	11,561	18,794	14,645	8,526	8,725	51,217	48,283	49,750
San Ramon ..	732	1,045	3,765	5,435	6,805	7,848	11,553	12,724	8,834	10,974	31,689	38,026	34,858
Bourbon* ..	0	0	2,803	3,569	8,062	13,097	14,290	20,031	14,742	12,578	39,897	49,275	44,586
Mean ..	995	1,284	7,173	7,930	8,063	10,290	15,597	15,354	9,455	8,466	41,086	43,068	

* Planted nine months later than other varieties.

TABLE 92. ACA2. COFFEE VARIETY x SPACING TRIAL

CONVERSION FACTORS AND YIELDS 1958–63 AS DRY COFFEE EQUIVALENT

Variety	Blue Mountain	Arusha	Mocha	San Ramon	Bourbon
Dry weight as Percentage cherry weight	14.35	11.41	13.21	12.60	12.62
Yield Dry Coffee (lb. per acre) ..	5,391	4,980	6,575	4,403	5,630

ACA2. Variety x Spacing Trial (Block B5)

Yields of varieties throughout the trial are shown in Table 91, and overall yield converted to dry coffee equivalent in Table 92.

In comparing varietal yields, account has to be taken of the fact that Bourbon was planted nine months later than the other varieties. Yields within the trial have been highly variable, and although analysis confirmed the differences between varieties, the apparent interaction between varieties and spacings has never been significant. One would expect this interaction to be real, at least in the case of San Ramon which is a much less vigorous variety than the others. The advantage of the closer spacings in the early years was statistically significant, but by 1962-63 the advantage had gone and the trend was in the opposite direction.

Conversion factors presented in Table 92 are the averages of the figures quoted in the 1960-61 Annual Report, being an expression of the oven-dry weight of hulled coffee as a percentage of cherry weights. Analysis showed the differences in recovery to be significant between varieties but not between spacings.

ACA9. Variety x Spacing x Pruning Trial (Block B14)

Details of this trial were given in the 1959-60 Annual Report. It compares four varieties, each at three spacings, with two pruning systems. Yields in 1961-62 and 1962-63 converted to a per acre basis are shown in Table 93. These are weights of cherry coffee, and results of ACA2 indicate that differences between varieties in recovery of dry coffee could substantially influence the relative performances of the varieties. Particularly with reference to the merits of the two pruning systems, it is too early yet to draw firm conclusions from this trial. Although the East African system has given higher yields so far, it is proving more difficult to produce suckers for new uprights than with the Agobiada system.

TABLE 93. ACA9. COFFEE VARIETY x SPACING x PRUNING TRIAL

YIELDS (LB. CHERRY COFFEE PER ACRE) 1961–63

Year	*Spacing*	*Pruning*	*Blue Mountain*	*Bourbon*	*Arusha*	*San Ramon*
1961–62 ..	9 ft. x 9 ft. ..	Agobiada ..	1,291	787	1,105	..
		East African ..	986	986	1,328	..
		Mean	1,138	886	1,216	..
	8 ft. x 6 ft. ..	Agobiada ..	2,178	830	2,436	1,626
		East African ..	2,851	2,322	2,740	2,330
		Mean	2,515	1,576	2,588	1,978
	8 ft. x 4½ ft. ..	Agobiada ..	3,022	2,786	3,722	2,481
		East African ..	3,981	3,633	3,953	2,880
		Mean	3,502	3,210	3,837	2,680
	5 ft. x 5 ft. ..	Agobiada ..	..	..	..	5,106
		East African ..	..	..	..	5,080
		Mean	..	..	..	5,093
1962–63 ..	9 ft. x 9 ft. ..	Agobiada ..	4,994	8,746	10,738	..
		East African ..	5,936	10,561	15,413	..
		Mean	5,465	9,653	13,075	..
	8 ft. x 6 ft. ..	Agobiada ..	8,471	7,126	18,140	5,442
		East African ..	11,709	21,542	22,171	9,038
		Mean	10,090	14,334	20,155	7,240
	8 ft. x 4½ ft. ..	Agobiada ..	10,736	19,815	27,732	8,206
		East African ..	13,436	22,287	27,469	11,700
		Mean	12,086	21,051	27,600	9,953
	5 ft. x 5 ft. ..	Agobiada ..	..	..	..	14,200
		East African ..	..	..	..	16,659
		Mean	..	..	..	15,429

*ACA*11. *Single Stem Pruning Trial* (*Block A*10)

Yield records up to March 1962 were statistically analysed but failed to show any significant differences between pruning treatments. This was probably the result of very high variability between replicates of the same treatment rather than of lack of differences between treatments. Pretreatment yields (1958) and circumference of stems both failed to be of use as covariates to improve precision of the experiment. Yields in 1962-63 were again highly variable and treatment differences were not significant in a simple analysis of variance. A summary of yields is shown in Table 94.

TABLE 94. ACA11. COFFEE SINGLE STEM PRUNING TRIAL

YIELDS (LB. CHERRY COFFEE PER PLOT) 1958 TO 1963

Treatment	*Pretreatment Yield 1958*	*Yield 1959–60*	*Yield 1960–61*	*Yield 1961–62*	*Yield 1962–63*
No pruning ..	461	949	1,014	949	873
Cut head primaries only ..	514	953	1,052	1,049	713
Single stem light ..	488	752	946	930	763
Single stem heavy ..	473	682	825	938	591
Colombian ..	411	780	935	883	708

*ACA*12. *No Shade-Fertilizer Trial* (*Block E*7)

A pilot trial was laid down in 1959 to study the response of mature coffee to fertilizer following the removal of shade. The coffee had been planted in 1954 with *Albizia* shade. Plots were of nine trees surrounded by a single row common guard, unfertilized. Treatments consisted of three levels of N, P and K, in an incomplete factorial design, with a basal dressing of minor elements. Yield records were maintained until July 1961, but plot variability was so high that it was felt that treatment effects could never be reliable and the trial was discontinued. It has been replaced by trial ACA 16.

*ACA*8. *Factorial Fertilizer Trials* (*Blocks A*15-16 *and E*7)

Two diagnostic trials were laid down in 1957 on young coffee growing on a hillside and a pit-pit soil. The coffee was the standard Blue Mountain variety under *Albizia stipulata* shade. Intended only as a short term diagnostic trial, three tree unguarded plots were used. Further fertilizer applications were made in 1958, 1959 and 1961. Elements considered were Ca, N, P, K, Mg and mixed minors, in a half replicate of 2^6 factorial, giving 32 plots.

As reported previously, in neither trial was it possible to isolate any individual element as giving a response, but rather there was a generalized improvement with fertilizing. In the case of the hillside block, this showed up primarily in survival of the seedlings in the establishment stage. The trial was laid out as a narrow strip across a 5-acre block of coffee seedlings, and within this strip about 90 per cent. of seedlings survived whereas outside about 90 per cent died. On the pit-pit soil also, much improved early growth was apparent in fertilized plots, though most seedlings survived whether fertilized or not. This result could be explained in one of two ways—

1. Stirring of the soil while applying fertilizer may have been beneficial.

2. Sulphur, which had not been considered as a possible deficiency, may in fact have been the limiting factor. The fertilizers used to supply N, Mg and minors all contained sulphur, so that only four of the treatments applied were sulphur free.

In support of the latter explanation the following may be noted—

(1) in observations recorded five months after fertilizer application on the hillside soil, no improvement was reported for the four no-sulphur plots, whereas most other plots were reported as showing some improvement.

(2) in similar observations on the pitpit soil four months after fertilizing, reports on the four no-sulphur plots were also less favourable than average.

(3) in the trial on pitpit soil, which was maintained to maturity, four trees had died in the four no-sulphur plots, compared with four deaths only in the 28 other plots.

Yield records were kept for the block on pitpit soil from 1959 to 1961, but after eliminating the effects of an obvious fertility gradient across the block, analysis revealed no response to any treatment. At this stage the small plot size rendered the trial unsatisfactory because of the probability of poaching between plots, and it was discontinued. The possibility of sulphur deficiency was examined further, and confirmed, in pot trials, but the results of this experiment and subsequent experience indicate that for coffee it may be critical only in the early establishment phase.

ACA4. Omission Method Fertilizer Trial (Block E7)

Small size of plots and lack of guarding led to some doubt as to the value of maintaining this trial, as it was designed to give results in early growth and production, but failed to do so. Statistical analysis of yields up to November 1961 did not show any nutrient effects as significant. However, trees were not generally very healthy, and it was decided to double the rates of nitrogen and potassium applied, and at the same time drains about a foot deep were dug around each plot to minimize transfer of fertilizers between plots. Yields for 1962-63 showed a much stronger indication of a potassium effect. Results are summarized in Table 95.

TABLE 95. ACA4. OMISSION METHOD FERTILIZER TRIAL ON COFFEE, AIYURA

TOTAL YIELDS (LB. CHERRY COFFEE) FROM 6 PLOTS OF 6 TREES

Treatment	*Total January 1959 to March 1961*	*April 1961 to March 1962*	*April 1962 to March 1963*	*Total*
1. Complete fertilizer	534	782	621	1,937
2. Less calcium sulphate ..	532	808	824	2,164
3. Less calcium hydroxide ..	496	750	823	2,069
4. Complete plus calcium hydroxide	603	836	712	2,151
5. Less phosphorus ..	674	930	812	2,416
6. Less nitrogen ..	472	691	685	1,848
7. Less potassium ..	532	603	438	1,573
8. Less magnesium ..	546	894	795	2,235
9. Less copper ..	640	881	884	2,405
10. Less zinc ..	613	811	803	2,227
11. Less molybdenum	442	730	668	1,840
12. Less iron ..	644	852	862	2,358
13. Less manganese ..	545	751	800	2,096
14. Complete fertilizer	535	703	991	2,229

ACA7. High Level Fertilizer Trial (Block E7)

Statistical analyses of yields up to October 1961 showed highly significant yield improvement of the fertilized over the unfertilized plots, and an increased yield of the higher potassium level over the lower, with no significant increase from the higher levels of phosphorus and nitrogen. It is not possible to determine from this trial whether phosphorus and nitrogen have given any benefit at the lower level, but foliar analyses support the indication that potassium is the main limiting element (see under *Agricultural Chemistry*).

Plate 14. Omission method fertilizer trial, Aiyura. The bush in the foreground, which showed severe defoliation at the end of the cropping season, is in a minus-potassium plot. Bushes in the background have received potassium fertilizer. (*Photo: A. E. Charles*)

Plate 15. High level fertilizer trial, Aiyura. The plot at the right, which shows severe defoliation, is a " no fertilizer " treatment: bushes on the left are in a " full fertilizer " plot. (*Photo: A. E. Charles*)

A summary of treatment main effects is given in Table 96.

TABLE 96. ACA7. HIGH LEVEL FERTILIZER TRIAL ON COFFEE, AIYURA

TREATMENT MAIN EFFECTS (MEANS: LB. CHERRY COFFEE PER 12 TREE PLOT)

Treatment	*1959–60*	*1960–61*	*1961–62*	*1962–63*
Nil ..	245.7	143.2	307.8	88.8
N_1 ..	311.9	218.6	517.0	158.7
N_2 ..	323.1	214.1	489.8	158.9
P_1 ..	326.3	238.1	496.0	175.9
P_2 ..	308.8	194.6	510.8	159.6
K_1 ..	307.3	195.9	443.9	103.1
K_2 ..	327.8	236.9	562.9	214.5

The yield increase between K_1 and K_2 in 1962-63 was of the order of 800 lb. dry coffee per acre. By 1963, the unfertilized plots, and generally also the K_1 plots, could be detected readily by eye because of lower vigour and extensive die-back (see Plate 15). The K effect is expected to increase greatly in the next main harvest.

ACA16. Factorial Fertilizer Trial (Block A15-16)

A new fertilizer trial was commenced in 1962 aimed to give more information on economic levels of fertilizing. Earlier trials had indicated no deficiencies other than the three major nutrients (N, P, K) and possibly sulphur, so the new trial is an NPK factorial and sulphur (as gypsum) is added to N_0 P_0 K_0 plots to ensure that sulphur will not be limiting. Because of indications from ACA1 that coffee yields better without shade, the trial will be grown without shade.

The site chosen was a block of reasonably even mature Blue Mountain coffee on a hillside soil, originally planted in 1955 with permanent shade. Shade was removed in November 1961.

Basal girths of all bushes were measured at a standard height of 8in. above the ground, for possible use as a covariate to adjust plot yields. Fertilizer was applied in March 1962. Design is a 4 x 2 x 3 factorial with two replicates, plot size 6 x 10 trees with 4 x 8 trees recorded for yield. Fertilizer levels used are:

Nitrogen: 0, 112, 224 and 448 lb. per acre sulphate of ammonia

Phosphorus: 0, 112 lb. per acre superphosphate.

Potassium: 0, 131 and 262 lb. per acre sulphate of potash.

Yields for 1962-63 are too early to reflect treatment effects, but showed great variability from plot to plot with a range from 455 to 1,934 lb. cherry coffee per plot. At June 1963, very pronounced variation was visible in health of the trees, with extensive dieback in places, but this was not obviously related to fertilizer treatment. Much of the coffee produced from the block was of poor quality, and some account of quality will have to be made in future yield records.

ACA8. Nitrogen-Sulphur Trial (Block E7)

As stated above under ACA16, there were indications of sulphur deficiency affecting coffee at Aiyura in some earlier trials, but results were somewhat inconclusive. It was thought undesirable to include sulphur as a treatment in ACA16, since commercial fertilizing would supply sulphur as a secondary ingredient of other fertilizers. Instead, a small trial was laid down in block E7 to study the effect of sulphur, and also the possibility that sulphur deficiency might limit nitrogen response.

The trial is located on mature Blue Mountain coffee planted at 9 ft. triangle spacing in February 1957.

Design is a 2 x 2 factorial with six replications, plot size 5 x 3 bushes with a single common guard surround. Fertilizer levels are:

Nitrogen: 0 and 156 lb. urea per acre per year.

Sulphur: 0 and 346 lb. gypsum per acre per year.

Fertilizer is applied every six months at half the annual rate, and includes a basal dressing of 2 cwt. per acre KC1.

First fertilizer was applied in March 1962, and the second dressing in November 1962. Yields for 1962-63 were very variable, and the NS plots gave very low yields, but at such an early stage this was probably not a fertilizer effect. Girths of all bushes were recorded, before treatments were applied, for possible use as a covariate to adjust later yields.

ACA15. Foliar Spray Trial (Block A10)

A simple trial was laid down in 1961 to test a commercial organic leaf spray, "Sea Magic," in comparison with inorganic fertilizers applied as sprays or to the soil. A randomized block trial with four replications was applied to mature Blue Mountain coffee (planted 1954) growing under *Albizia stipulata* shade. Treatments were:

1. Control—no treatment.
2. "Sea magic" spray—1 gal. per acre twice a year.
3. Urea spray, to supply the same quantity of nitrogen as in "Sea Magic" treatment.
4. Inorganic leaf spray, to supply approximately the same quantities of all mineral nutrients as in "Sea Magic" treatments.
5. NPK fertilizer as soil dressing, equivalent in cost to the "Sea Magic" treatment (2 cwt. per acre "Nitrophoska green" plus 28 lb. per acre "Phytona" trace element mixture).

Yields are shown in Table 97.

TABLE 97. ACA15. COFFEE FOLIAR SPRAY TRIAL, AIYURA

YIELDS (LB. CHERRY COFFEE PER PLOT PER ANNUM)

Treatment	*Pretreatment Yields April 1959 to March 1961*	*March 1961 to April 1962*	*March 1962 to April 1963*	*Average 1961–63*
Control ..	460	466	356	411
"Sea Magic" ..	409	579	342	461
Urea	370	442	375	409
Inorganic Mixture	369	496	296	396
NPK + minors ..	359	547	497	522

ACA29. Mulch-Fertilizer Trial

Following failure of the *Grevillea* trees in ACA1, they were removed in August 1961, and in November 1961, combinations of mulch and fertilizer were applied orthogonally to spacing and pruning over the pairs of replicates 1, 2; 3, 4; 5, 6; and 7, 8. The comparisons on the pit-pit soil (replicates 1-4) were mulch vs. no mulch, without fertilizer, and on the hillside soil (replicates 5-8), fertilizer vs. no fertilizer in the presence of mulch. In addition, some comparison of fertilizer vs. no fertilizer can be made on the pit-pit soil, and between mulch and no mulch on the hillside soil, by including the original no-shade plots which were fertilized at the same time and rates.

Yields in 1962-63, as pounds cherry coffee per acre, were as follows—

Pit-pit Soil—	
No mulch, no fertilizer ..	6,818
Mulch, no fertilizer ..	7,368
No mulch, fertilizer	14,109
Hillside Soil—	
Mulch, no fertilizer ..	20,177
Mulch, fertilizer	19,551
No mulch, fertilizer ..	20,908

The main effect indicated is a response to fertilizer on the pit-pit soil.

ACA14. Mulch-Fertilizer Trial

Following completion of the cultural methods x spacing trial (ACA3) in block C3, steps were taken to even out the block for application of new mulch-fertilizer combinations. In 1962 the whole block was mulched, shade was removed, and replants were made where necessary. The trees are also being converted to multiple stem pruning, as this is standard plantation practice. The conversion technique used was removal of all laterals on one side, the south east side being chosen, and cutting of a wedge in the main stem about 18 in. above the ground. Three new uprights are being brought up from just below this cut. As these develop, the remaining laterals will be removed, finally cutting off the original stem at the wedge.

The following four treatments will be compared on this block—

Clean weeding, no fertilizer

Clean weeding, fertilizer

Mulch, no fertilizer

Mulch, fertilizer

The treatments will be applied orthogonally to the existing treatments and blocks.

TRIALS AT OUTSTATIONS

Small trials are located at Goroka and Korn Farm, Mt. Hagen, to give results in different localities for comparison with those obtained in the larger trials at Aiyura.

ACA18. Variety Trial, Goroka

This is a simple comparison of six varieties at 9 ft. triangle spacing under *Albizia stipulata* shade. It was planted early in 1956. There are two replicates in a randomized block design, with 28 tree plots. Yields up to 1963 are shown in Table 98.

TABLE 98. COFFEE VARIETY TRIAL, GOROKA

YIELDS (LB. CHERRY COFFEE PER PLOT) 1959–63

Variety	*February—March 1959*	*1959–60*	*1960–61*	*1961–62*	*1962–63*	*Total*
Hawaiian Kona	7.5	193.5	340.5	121.0	306.5	969
Blue Mountain	11.0	342.5	389.5	104.5	341.3	1,189
Mocha	8.5	267.0	416.0	172 0	239.3	1,103
Arusha	3.5	487.0	504.5	245.5	271.3	1,511
San Ramon-Tall	18.0	259.0	299.0	72.5	201.0	849
San Ramon-Dwarf ..	2.5	112.5	148.0	61.0	194.8	519
Least significant difference—						
5 per cent.	8.5	190.3	32.5	44.2	109	..
1 per cent.	13.4	298.4	51.0	69.2	171	

TABLE 99. ACA19. COFFEE SHADE x PRUNING TRIAL, GOROKA

Average Yields of Main Treatments (lb. cherry coffee per acre)

Treatment	December 1958 to March 1959	1959–60	1960–61	1961–62	1962–63	Total
Single stem	2,018	9,667	16,575	4,922	21,918	55,100
Multiple stem	2,984	16,577	17,543	5,562	22,056	64,722
No shade	1,993	8,759	17,906	6,543	18,600	53,801
Albizia stipulata	1,862	12,101	12,896	3,860	23,576	54,296
Local *Albizia* sp.*	2,231	16,582	16,150	5,767	22,259	62,989
Grevillea robusta	3,104	14,579	20,297	4,874	23,564	66,418
Casuarina	3,313	13,590	18,047	5,165	21,939	62,053

* Now identified as *Albizia fulva*.

ACA19. Shade x Pruning Trial, Goroka

This trial contains unreplicated plots of five shade tree species, split for single and multiple stem pruning comparison. It was planted with Blue Mountain variety in March 1955. It was split in 1961, at right angles to the split for pruning, and a complete fertilizer mixture was applied to half the area.

A summary of yields is presented in Table 99.

Results in this location have differed from those at Aiyura. Multiple stem pruning has consistently resulted in higher yields, while the nil shade treatment has fairly consistently given poorer yields than shaded treatments. *Albizia stipulata* has made the best growth of the shade species used, and relatively poor yields under this species may have been a result of excessive shading. The local *Albizia* species grew poorly, *Casuarina* proved short lived, although replanting was quite practicable when deaths occurred, and *Grevillea* was severely attacked by pests at times.

ACA20. Coffee Spacing x Pruning Trial, Goroka

A randomized block trial with two replications of four spacings, plots split for comparison of single and multiple stem pruning. The single-stem treatments were stumped back for conversion to multiple-stem in February 1962, as the superiority of the latter was well established. Results are summarized in Table 100.

TABLE 100. ACA20. COFFEE SPACING x PRUNING TRIAL, GOROKA

Average Yields of Main Treatments (lb. cherry coffee per acre)

Treatment	December 1958 to March 1959	1959–60	1960–61	1961–62	Total 1958–1962	1962–63*
Single stem pruning	831	9,092	8,094	4,712	23,729	..
Multiple stem pruning	1,105	13,160	10,958	6,562	31,785	10,166
7 ft. x 7 ft. spacing	1,125	14,369	9,627	6,170	31,291	11,760
8 ft. x 8 ft. spacing	1,031	10,834	9,766	7,125	28,756	9,205
9 ft. x 9 ft. spacing	798	10,074	10,115	5,944	26,930	11,662
12 ft. x 6 ft. spacing	919	9,222	8,595	5,310	24,052	8,036

* Multiple-stem plots only.

ACA21. High Level Fertilizer Trial, Goroka

This trial is identical in design and treatments with ACA7 described above.

Results are summarized in Table 101. There have been no significant increases in yield between the higher and lower levels of fertilizer applications, but all fertilized plots outyielded the unfertilized plots. Foliar analyses (*see* under *Agricultural Chemistry*) have indicated a satisfactory nutrient status of coffee on these soils.

TABLE 101. ACA21. HIGH LEVEL FERTILIZER TRIAL ON COFFEE, GOROKA

TREATMENT MAIN EFFECTS (MEANS: LB. CHERRY COFFEE PER 12 TREE PLOT)

Treatment	*1959–60*	*1960–61*	*1961–62*	*1962–63*
Nil ..	173.3	229.5	39.5	162.8
N_1 ..	182.9	288.9	41.5	242.5
N_2 ..	189.6	269.6	43.0	220.2
P_1 ..	197.0	289.4	44.6	233.7
P_2 ..	175.5	269.1	39.9	229.0
K_1 ..	188.9	284.5	43.1	231.3
K_2 ..	183.6	274.0	41.4	231.3

ACA22. Shade x Pruning Trial, Korn Farm

This trial is basically similar to ACA19, but includes a larger number of shade species. It was planted in March 1956. Results are summarized in Table 102.

TABLE 102. ACA22. COFFEE SHADE x PRUNING TRIAL, KORN FARM

AVERAGE YIELDS OF MAIN TREATMENTS (LB. CHERRY COFFEE PER PLOT)

Treatment	*1959–60*	*1960–61*	*1961–62*	*1962–63*	*Total*
Single Stem ..	435	962	1,699	1,146	4,242
Multiple Stem	561	1,417	1,778	1,069	4,825
No Shade ..	307	1,210	1,488	1,480	4,486
Casuarina ..	292	1,066	1,248	791	3,397
Gliricidia ..	514	1,457	1,560	945	4,477
Albizia stipulata	602	1,150	1,698	1,395	4,846
Leucaena glauca	540	1,248	1,840	1,089	4,717
Grevillea robusta	393	1,081	1,978	1,247	4,699
Peltophorum ..	709	1,231	2,299	1,072	5,312
Piptadenia ..	627	1,069	1,795	840	4,332

Gliricidia, Peltophorum and *Piptadenia* all made very poor growth and are virtually non-existent in their plots. Thus it is doubtful whether any significance can be attached to the relative yields under the different shade species.

ACA23. Variety x Spacing Trial, Korn Farm

This trial compares five varieties at two spacings with two replicates. The varieties are Blue Mountain, San Ramon, Arusha, Mocha and Bourbon. It was planted in March 1956.

Varieties Mocha and Arusha have outyielded the other three, and 7 x 7 ft. spacing has consistently outyielded 9 x 9 ft.

ACA25. High Level Fertilizer Trial, Korn Farm

This trial is basically similar to ACA7, but includes a third level of potassium, at a rate of 5 cwt. KCl per acre per annum, is pruned to a multiple-stem system and is unshaded. As at Aiyura, results indicate increased yield of all fertilized plots over the unfertilized plots, and an increase from the lowest to the second level of potassium, but not for any other element. Foliar analyses indicate that potassium is the main limiting element but not so deficient as at Aiyura. Main effects of fertilizers on yield are shown in Table 103.

TABLE 103. ACA25. HIGH LEVEL FERTILIZER TRIAL ON COFFEE, KORN FARM

TREATMENT MAIN EFFECTS (MEANS: LB. CHERRY COFFEE PER 12 TREE PLOT)

Treatment	*1959–60*	*1960–61*	*1961–62*	*1962–63*
Nil ..	169.3	107.5	113.3	179.5
N_1 ..	220.7	232.7	208.7	320.6
N_2 ..	220 2	229.4	226.2	279.2
P_1 ..	211.3	232.6	210.2	298.3
P_2 ..	229.6	229.6	224.7	301.5
K_1 ..	240 0	218.0	203.3	264.5
K_2 ..	229.1	247.3	222.3	310.5
K_3 ..	208.1	244.6	242.4	324.7

MISCELLANEOUS

ASF3. Pot Tests for Sulphur Deficiency

Following indications of sulphur deficiency in coffee field trials, pot tests were made in 1962, using maize and tomatoes as indicator plants. Growth of the plants showed a clear sulphur response on soil from the hillside block A15-16 where so much difficulty had been experienced with coffee establishment (*see* ACA 8). Indications of a less severe deficiency were obtained on soil from the pit-pit block E7 where the other diagnostic trial had been carried out. Tests on another pit-pit soil from a lower level (block H7) showed little or no sulphur response. These results will be published in detail when further chemical analyses have been completed.

Coffee Deficiency Symptoms

A series of coffee plants has been established in pure sand in large pots, each being fed with a nutrient solution deficient in one major element. The aim is to induce deficiency symptoms so that they can be described and photographed, to enable their subsequent recognition in the field. Deficiencies being induced are nitrogen, potassium, calcium, magnesium, sulphur and phosphorous.

Measurement of Shade Intensity

In comparing results of coffee experiments in different localities, and in assessing the effect of different shade species, it is necessary to have some absolute measurement of light intensity reaching the coffee trees. Such measurement is difficult to obtain because so many variables are involved.

In 1961 and 1962, trials were made of measuring light intensity under shade trees with an EEL Lightmaster photometer reading in foot candles with three ranges of sensitivity, 0-15, 0-150 and 0-1,500. A major difficulty in use of the meter was that, with movement of foliage causing variations from full sunlight to shade, it was often impossible to obtain a steady reading. It was possible to overcome this by shielding the meter from direct sunlight, and in this way fairly consistent readings were obtained showing differences in light received under different levels of the same shade tree species. However, shielding from the sun had removed the main source of incident light, so the method could not be considered satisfactory. Later studies involved a chemical method which aimed to measure total light received over a period of several hours. Details of the method are described in the report of the Agricultural Chemistry section. The method is being further investigated, as it would appear that it gives satisfactory results, but it is too laborious to apply on a large scale.

PYRETHRUM BREEDING AND AGRONOMY

Selection of Clones

Difficulties arose in the clonal selection work from contamination by self-sown seedlings. Where their purity was in doubt, clones were multiplied and carefully checked to eradicate seedling contamination, and all clonal multiplication plots are now harvested once a week to ensure that no seed can fall to the ground.

Sixty-six single plants were selected from seedling lines in April 1963 and established in clonal lines. Seventy-four earlier clonal selections, not yet tested for pyrethrins content, have been kept under observation. Several of these will be eliminated as agronomically unsatisfactory.

Environmental Influence on Varietal Yields

The Aiyura Experiment Station is sited at an elevation of 5,400 ft. above sea level. This is below the optimum altitude for pyrethrum culture. Flowering of pyrethrum is particularly responsive to temperatures below 54° F., and optimum conditions are warm sunny days and cold nights, with abundant rainfall. Relevant climatic data for Aiyura for the period 1952 to 1961 are shown in Table 104.

TABLE 104. CLIMATOLOGICAL DATA, AIYURA

AVERAGE FOR TEN YEARS 1952–61

	Jan.	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*August*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
Temperature:												
No. of recordings below 54°F	2.2	1.0	1.5	1.0	5.5	9.0	9.1	4.8	6.0	7.1	6.1	1.9
Average minimum (degrees F)	56.8	57.8	57.0	56.8	56.5	56.0	55.0	55.8	55.2	54.7	55.0	56.9
Lowest monthly recording (degrees F)	46.0	50.0	51.0	51.0	45.0	45.0	45.0	41.0	45.0	42.0	45.0	47.0
Average maximum (degrees F)	75.0	75.1	75.8	74.2	74.3	72.8	71.0	71.0	72.0	73.8	74.6	75.0
Sunshine .. (hours)	113	116	115	121	176	117	154	145	149	188	127	120
Monthly rainfall (inches)	9.34	10.88	10.01	10.13	4.51	3.78	4.02	5.61	5.02	6.22	7.92	9.40

The problem arises of whether selection under Aiyura conditions will be valid for the areas at higher altitude where the crop will be grown commercially. A preliminary study of environmental effects was commenced in 1961-62 with the planting of a single variety (AP78/65 x AP50) in 27 plots in a variety of localities at altitudes ranging from 5,000 to 8,200 ft. Observations made on some of these plots in 1962-63 are shown in Table 105.

APC4. Variety x Environment Trial

For a more accurate assessment of the influence of environment on comparative performance of different varieties, a formal trial is to be laid down with six clones. Sites have been selected at altitudes of 6,000 and 7,000 ft. on the Okapa Road for comparison with Aiyura.

Breeding

Six clones which showed promise for growth, yield, and pyrethrins content, were selected as parents for use in biclonal seed gardens. The following combinations were established in isolated plots—

AP78/65 x AP65	AP65 x AP70
AP78/65 x AP70	AP65 x AP58
AP78/65 x AP58	AP65 x AP102
AP78/65 x AP102	AP65 x AP78
AP78/65 x AP78	AP102 x AP70

In addition, small biclonal plots were established in block D10. These are to be covered with wire cages and blowflies are to be released into the cages as pollinating agents. With the need to test increasing numbers of combinations, some technique such as this is becoming necessary, as adequate isolation can no longer be assured.

APC2. Variety x Spacing Trial

This trial was laid down in March 1962 to compare 3 varieties at 3 spacings. Design is a randomized block with 6 replications, the main plots for varieties being split for spacing comparisons.

Varieties: AP78/65 x AP50
AP70 x AP82
AP65 x AP66 x AP76
Spacings: 2 ft. x 1 ft.
2 ft. x 1 ft. 6 in.
2 ft. x 2 ft.

In the first year's flowering, AP78/65 x AP50 outyielded the other two varieties. The two closer spacings gave similar yields, but plants at 2 ft. x 1 ft. 6 in. looked much healthier. Yield at 2 ft. x 2 ft. was lower.

Seed Production

Thirty-six pounds of F1 seed of AP78/65 x AP50 was distributed between November 1962, and March 1963. The seed garden was then extended to approximately 3½ acres.

With the expanded planting programme, it was found impossible to supply sufficient F_1 seed of this cross to meet requirements, and F_2 seed has had to be used as well. To determine whether F_1 seed has any advantage over F_2 a new trial is to be put out. It will be a simple randomized block design with ten replicates.

TABLE 105. PERFORMANCE OF PYRETHRUM IN DIFFERENT LOCALITIES

Altitude (feet)	*Region*	*Peak Flowering Period*	*Flower Size*	*Plant Vigour*	*Total Pyrethrins (per cent. dry weight)*
8,200	Chimbu	January-June	Normal	Good	2.20
8,100	Goroka	November-December	Very good	Good	2.47
7,775	Chimbu	December–June	Normal	Good	..
7,000	Chuave	October–December	Very good	Good	..
6,975	Chimbu	January	Normal	Good	..
6,800	Henganofi	October–December	Good	Very good	2.52
6,700	Wabag	November–January	Very good	Very good	..
6,700	Chimbu	December–May	Normal	Poor	2.37
6,500	Goroka	December–January	Good	Good	2.10
6,000	Chuave	October–November	Good	Very poor	2.09
5,800	Henganofi	October–December	Good	Good	1.89
5,700	Goroka	October–January	Good	Good	1.98
5,200	Kagua	..	Fair	Very good	..
5,100	Goroka	November–December	Poor	Poor	1.64
5,000	Chuave	November–December	Good	Good	2.13
4,800	Henganofi	October–December	Poor	Poor	1.79

APC1. Fertilizer Trial

This trial was laid down in March 1962, with six replications of six treatments. The treatments and yields of flowers in the first year are shown in Table 106.

TABLE 106. APC1. PYRETHRUM FERTILIZER TRIAL
YIELDS AS POUNDS DRY FLOWERS PER ACRE 1962–63

Treatment (quantity fertilizer per acre)	*Yield*
1. No fertilizer	609
2. 1 cwt. superphosphate	672
3. 2 cwt. superphosphate	674
4. 4 cwt. superphosphate	654
5. 2 cwt. superphosphate + 2 cwt. rock phosphate	641
6. 2 cwt. superphosphate + 2 cwt. sulphate of ammonia*	728

* Sulphate of ammonia added as a side dressing in May 1962.

FOOD CROP AGRONOMY AND SOIL FERTILITY STUDIES

ASF1. Soil Exhaustion Trial

The soil exhaustion trial has now reached the thirteenth planting (8th year). Although in the earlier years differences between treatments suggested a more rapid decline in fertility than at Keravat, current yields are high, averaging about 20,000 lb. per acre at the 12th planting. Unfortunately the variety of sweet potato was changed at some stage of the trial and this will complicate interpretation of the results.

ASF2. Crop Rotation Trial

This trial has now completed the second cycle. Yields of sweet potato have been maintained at a fairly high level, but yield totals of the different rotations indicate that the shorter rotations are declining relative to the longer rotations. As with the soil exhaustion trial, interpretation has been complicated by a change in sweet potato variety.

AIB1. Sweet Potato Management Trial

This trial was concluded after three and a half years. The harvesting and replanting method gave higher yields than the village management practice. However, it is doubtful whether the village management technique was applied as carefully as in actual village practice, where women rather than men harvest and manage the gardens.

AIB2. Sweet Potato Variety Trial

A new trial was planted in April 1963, to compare yield and protein content of ten sweet potato varieties.

Ten varieties introduced from New Zealand for test for frost resistance are being multiplied preliminary to trial. Two varieties from Chimbu were also similarly planted for multiplication.

AGM1. Soya Bean Variety Trial

Interest in this crop has stemmed primarily from its nutritional value, and chemical analyses have been associated with agronomic studies.

A variety trial was planted in November 1961, to compare yields of fifteen varieties, and to study the effect of inoculation of the seed with *Rhizobium*. The trial was laid out in a randomized block design with four replications, with the variety plots split for inoculation versus no inoculation comparison. Main plots were 20 ft. x 20 ft., but were divided into four beds by drains approximately 1 ft. wide by 1 ft. deep, and similar drains surrounded each plot. Two beds formed each sub-plot. Seed was planted at a spacing of 1 ft. x 6 in. Two seeds were planted at each point, thinned to one plant per point after germination, with misses replaced where necessary. Seed inoculation was carried out by mixing the bacterial inoculum with water, pouring it over the seeds, and thoroughly mixing, immediately prior to planting. All uninoculated plots were planted before inoculation was commenced.

Notes on the varieties and yields (converted to pounds per acre) are shown in Table 107. The two varieties Blyvoor and Geduld were planted in only two replications each, owing to seed shortage, and their yields were excluded from the analysis of variance.

Later maturing varieties suffered greater damage from insect attack than those harvested earlier, but even allowing for this, the two Mamloxi varieties were clearly inferior in yield. Yield from inoculated plants was about 2½ per cent. greater than from uninoculated plants, but the difference did not approach statistical significance and was not at all consistent, nor was there any sign of response in vigour or colour of the plants during growth.

In 1963, plots of most of these varieties were planted at Aiyura, Minj, Wabag and Laiagam, in order to compare their performance at different localities and altitudes. Seed from these plots was to be analysed for protein and oil content. The first samples had been received by June, and analysis showed considerable variation between locations.

TABLE 107. AGM1. SOYA BEAN VARIETY TRIAL, 1962

DESCRIPTIONS OF VARIETIES, WITH YIELDS

Introduction No.	*Variety Name and/or Origin*	*Seed Description*	*Time to Mature*	*Yield*
			Months	Lb. per Acre
4661 ..	Batavian Yellow, Tanganyika ..	Shiny black	4½	1,990
4662 ..	Tanganyika	Large, dull black	5	2,643
4664 ..	CN 5, Tanganyika	Small, yellow	5½	1,582
4665 ..	Glycine 317, Tanganyika ..	Small, yellow	5½	1,742
4666 ..	Hernon 49, Tanganyika	Large, yellow; some with purple tinge ..	5	2,330
4667 ..	Mamloxi, Nigeria	Small, yellow; some with green tinge ..	6	716
4668 ..	Mamloxi 57/5, Nigeria	Yellow	6	438
4669 ..	Avoyelles, Nigeria	Black, yellow and brown seeds mixed ..	5	2,366
4670 ..	SHE 30, Congo	Large, yellow	5	1,900
4671 ..	Ringgit, Indonesia	Small, yellow; some with green tinge ..	6	1,462
4929 ..	Blyvoor, South Africa	Large, yellow; some with purple tinge ..	5	2,014
4930 ..	Geduld, South Africa	Large, yellow; some with purple tinge ..	5½	1,639
..	Coral Sea Mission, Goroka ..	Large, dull black; some yellow with black tinge	5½	2,407
..	Baptist Mission, Baiyer River ..	Large, yellow with black tinge	5	2,175
	Least significant difference between variety yields—			
	5 per cent.			229
	1 per cent.			308
	0.1 per cent.			406

Wheat

In 1962, 115 varieties of wheat obtained from the United States Department of Agriculture were planted for observation, together with bulk samples of *Triticum durum* and *T. aestivum* varieties grown within 15° of the equator.

Of the named varieties only fifteen set seed at the first planting. Seed harvested from these fifteen varieties was planted in 1963, but four varieties failed to germinate and five others germinated only poorly.

At the first planting of the bulk samples, the following results were obtained.

Species	*Heads with Seed*	*Heads without Seed*
T. durum	986	1,887
T. aestivum ..	1,488	2,834

Onions

In the past, good results have been obtained with Hybrid Granex Brown onions. However, as it is a true F_1 hybrid, seed is costly and has to be imported fresh for every planting. Other pure breeding lines were therefore grown for comparison to see whether any of them gave satisfactory performance. In 1961-62, Hybrid Granex Brown and Hybrid Granex White were grown alongside the parental varieties Crystal Grano White and Early Grano Brown, and three South African varieties (De Wildt, Early Flat Cape-Stellenbosch line and Early Flat Cape-Oudtshoorn line) which had been developed for use in high altitude equatorial regions. All varieties produced bulbs comparable to Hybrid Granex Brown in this season, but in 1962-63, the South African varieties failed to develop bulbs. Further tests will be made.

Sugar Beet

Several varieties introduced in 1962 made good early growth but the plants died when about 2 in. high. Condition of the roots suggested probable eelworm infection.

MISCELLANEOUS

Pastures

No formal trials were carried out, but observations made on species introduced over a number of years indicate the following to be most useful—

Grasses	*Legumes*
Pennisetum purpureum	*Glycine javanica*
P. clandestinum	*Desmodium canum*
Panicum coloratum	*D. uncinatum*
Paspalum urvillei	Siratro
Other *Paspalum* species	
Setaria sphacelata	
Hyparrhenia rufa	
Digitaria decumbens	

Leucaena glauca

Peru and El Salvador strains both made more vigorous growth than the local strain, and appeared equal to each other.

Herbicides

Observations were made on effectiveness of various herbicides for weed control in coffee, together with the possibility of injury to the crop. All tests were applied with a knapsack spray at a rate of about 180 gallons per acre.

Gramevin (2-2 dichloropropionic acid): A herbicide for grass species with effect showing about four weeks after application. *Phragmites* (reed) was controlled by 16 lb. per acre, with best results when about 4 ft. high. Kikuyu and couch grass were severely checked by application at 8 lb. per acre on leafy growth, but follow up spot spraying was necessary 8 to 12 weeks later. *Commelina* was checked by 16 lb. per acre. The spray should be kept away from coffee foliage, although injury is not severe. Care would need to be taken that control of grass did not lead to infestation by species such as *Sida*.

Lane's K.O. Weedicide (Sodium chlorate, TCA, and hormone mixture): A complete weed killer, with immediate effect. At 112 lb. per acre, it gave good grass kill but spot spraying was necessary again after eight weeks. It was toxic to coffee both on contact with leaves and on contact with soil where coffee roots were present. It could not be recommended for coffee weeding.

Weedazol 50 (Amitrol): A herbicide controlling monocots and various dicots, with a delayed action over four to six weeks. At 16 lb. per acre, this preparation inhibited all grasses and soft weeds. Regrowth of grasses and new seedlings of soft weeds occurred in twelve to sixteen weeks. It was toxic to coffee on contact with foliage.

Triazines: Pre-emergence herbicides, applied after a clean weeding to eliminate all crown growth. Gesatop (Simazine 50W) and Gesaprim (Atrazine 50W) at rates of 4 lb. and 8 lb. of commercial preparation per acre prevented germination of grass and weed seeds for fourteen weeks or longer.

Costs of all the treatments were considerably in excess of a single hand-weeding, and under present cost structure usefulness of herbicides would probably be limited to—

(a) 2-2 dichloropropionic acid on troublesome stands of stoloniferous grasses in coffee or cultivation and on grass-bound drainage ditches.

(b) pre-emergence herbicides applied after a clean-weeding, immediately before the peak harvest when labour frequently cannot be made available for weeding operations.

Fish

The Golden Carp liberated in Febuary 1961 had reached an average weight of about 9 lb. by December, when they were twelve months old. Subsequently they attained weights up to 16 lb. at about two years of age. Some 3,000 fingerling progeny of the original introductions were distributed to other Departmental stations, plantations, missions and villages.

Fifty-five Cantonese Carp were introduced in December 1961, and have bred successfully, but do not appear to attain the size of the Golden Carp. By August 1962, their average weight was only 1½ lb. and the largest specimen obtained since then had reached only 2½ lb. However, no data are available on comparative yields of the two species when numbers as well as weight are considered.

AGRICULTURAL EXPERIMENT STATION, EPO

Epo lies in the rain-shadow zone of the Central District of Papua and is located about 70 miles west of Port Moresby. A description of the station was given in the 1959-60 Annual Report, and rainfall data are shown in Appendix IV of this report.

RICE

INTRODUCTIONS AND BREEDING WORK

EOS6. Field Trials of Breeding Material

In 1962, a series of three field trials was laid down to compare yields of the Japonica x Indica hybrids, other introductions, and locally produced hybrids. Each trial was a randomized block of 20 varieties with three replicates, plots being 15 ft. square separated by paths 3 ft. wide.

TABLE 108. EOS6. YIELDS OF RICE INTRODUCTIONS AT EPO, 1962–63

Trial 1		*Trial 2*		*Trial 3*	
Variety	*Yield*	*Variety*	*Yield*	*Variety*	*Yield*
	lb. per acre		lb. per acre		lb. per acre
NG 4973 A	2,328	NG 4973 B	3,328	Epo Hybrid No. 7	2,399
NG 4974	2,120	NG 4963	640	Epo Hybrid No. 4	2,216
NG 4976	1,808	NG 4962	196	NG 4976 A	2,048
Epo Hybrid No. 7	1,992	NG 4958	124	Epo Hybrid No. 6	1,048
IJ55.6.13.2.0.0.	1,728	NG 4964	116	Epo Hybrid No. 21	942
IJ55.1.2.7.0.1.	1,712	NG 4959	92	Epo Hybrid No. 19	668
Epo Hybrid No. 4	1,648	NG 4967 A	68	NG 4967 B	632
IJ55/58 A.1	1,544	NG 4955	40	Epo Hybrid No. 15	440
NG 4972	1,504	NG 4974	56	Epo Hybrid No. 17	340
NG 4977	1,336	NG 4968	56	Epo Hybrid No. 12	272
NG 4978	1,288	NG 4966	44	Epo Hybrid No. 14	121
IJ.55.6.16.4.0.2.	1,112	NG 4954	36	Epo Hybrid No. 5	92
IJ55.4.23.0.1.	1,048	NG 4967 B	32	Epo Hybrid No. 9	72
Epo Hybrid No. 3	600	NG 4952	24	Epo Hybrid No. 20	68
IJ55.6.16.4.0.1.	576	NG 4965	24	Epo Hybrid No. 11	52
Epo Hybrid No. 35	160	NG 4953	20	Epo Hybrid No. 18	48
IJ55.4.22.0.1.	116	NG 4956	16	Epo Hybrid No. 13	44
Epo Hybrid No. 8	28	NG 4976	16	Epo Hybrid No. 10	32
Epo Hybrid No. 23	24	NG 4960	12	Epo Hybrid No. 22	24
Epo Hybrid No. 22	12	NG 4951	12	Epo Hybrid No. 16	20

Least significant differences: Trial 1: 5 per cent.; 658; 1 per cent.: 875; 0.1 per cent.: 1,150. Trial 2: Not analysed. Trial 3: 5 per cent.: 608; 1 per cent.: 808; 0.1 per cent.: 1,063.

The trials were sown late July to early August, 1962, and grown under flood irrigation. Acute nitrogen deficiency symptoms appeared after two months, and unfortunately no fertilizer was available at the time. As a result, flowering was poor and heads failed to fill. In January, 1963, when an NPK fertilizer became available, the trials were cut back to 3 in. above ground level and fertilized. They were then irrigated again, and were given a further fertilizer dressing before harvest in June 1963. Yields are shown in Table 108.

Trial 2 was unsatisfactory, with only one variety producing a satisfactory yield. This was in most cases due to failure of establishment, so that no indication of potential yield was obtained. Trials 1 and 3 were reasonably consistent though not very accurate, but the unusual growing conditions must be taken into account in assessing the results.

Indica-Japonica Hybrids: Of the seven selections tested in Trial 1 (prefaced IJ in Table 108), three gave fairly promising yields.

"Bulu" Selections: Introductions numbered NG4950 to NG4968 were "Bulu" selections from Indonesia, believed to be non-sensitive to photo-period. In trial 2, germination was poor and growth also was poor, resulting in quite unsatisfactory establishment for trial purposes.

Fiji Introductions: Introductions numbered NG4972 to 4978 were obtained originally from the Department of Agriculture, Suva, Fiji. Two slightly different types in NG4973 were designated A and B. In general, these varieties showed greatest promise of all those tested.

Epo hybrids: Amongst selections from crosses made at Epo, numbers 7, 4 and 6 showed the greatest promise.

Philippine Introductions: The four varieties introduced from the Philippines failed to germinate and have been lost.

EOS5. Pure Line Seed Production

As described in the 1960-61 Annual Report, a programme of continuous selection for pure seed production was commenced. The following varieties are now included—

A1	Blue Bonnet (R8)	R2
Anbar Bau	Blue Bonnet (22)	R3
B1	E1	R6
B2	52/16.0.2	Swizu
B3	K1	Toen Toeng
Gopher Short	Mekeo White	TP1252
Blue Bonnet	Mekeo White (awned)	147

Eight varieties included in the first round of selections reached the stage of planting in 1/20 acre

seed increase plots in early 1963. Yields are shown in Table 109.

TABLE 109. YIELDS OF PURE LINE RICE SEED, 1963

Variety	*Yield*	*Variety*	*Yield*
	lb. per acre		lb. per acre
Toen Toeng ..	1,680	Gopher Short	1,100
E1 ..	1,640	52/16.0.2 ..	980
TP 1252 ..	1,340	Anbar Bau ..	940
Blue Bonnet ..	1,210	Mekeo White	790

VARIETY TRIALS

EOS3. Dry Land

Variety trials have been conducted each year since 1960 to compare the most promising varieties. Yields are shown in Table 110 for 1960 to 1962. Not all varieties were included in 1961 and 1962 trials. In 1963 establishment was very poor and only E1 had a satisfactory stand, yielding at the rate of 3,150 lb. per acre. On the whole, results reflect variability in seasonal conditions rather than giving a reliable differentiation between varieties. In all trials, plots were 15 ft. square, separated by 3 ft. paths, with 3 replications.

TABLE 110. EOS3. RICE VARIETY TRIALS, DRY LAND

YIELDS IN POUNDS PER ACRE

Variety	*1960*	*1961*	*1962*
E1	3,161	729	1,871
K1	2,774	649	1,548
Blue Bonnet ..	2,516	935	2,064
Mekeo White ..	1,935	..	2,129
Anbar Bau ..	1,806	..	1,742
52/16.0.2 ..	1,677	..	2,000
TP 1252 ..	1,677	1,245	1,419
TP 352	1,613	782	..
TP 145	1,419	..	..
Toen Toeng ..	1,097	899	1,871
Magnolia ..	1,032	..	..
Least significant difference—			
5 per cent ..	851	Not significant	368
1 per cent. ..	1,142	..	445

EOS2. Irrigated

An unreplicated variety trial was commenced in June 1961, largely for the purpose of gaining experience with irrigated rice. Transplanting of seedlings into flooded fields was found to reduce weed control problems, but stemborer and leaf roller damage was very severe in July and August, and birds caused heavy grain losses after flowering. Growth from the June planting was stunted and spindly and flowering was uneven, showing the varieties to be photo-sensitive and unsatisfactory for dry season (winter) cultivation. A second crop matured in December and gave moderate yields (up to 1,800 lb. per acre), but not truly indicative of the individual varieties' potentialities. Another planting, commenced in July 1961, gave yields averaging better than 2,000 lb. per acre, though still non-uniform.

A trial of 8 varieties with 3 replications and plot area 1,050 sq. ft., was drill sown on 1st November 1961. Growth was tall, vigorous and healthy, disease and insect pests were negligible, but small birds caused very serious loss of grain at maturity, estimated at 50 per cent. for some varieties. Variety E1 gave highest yield at the first harvest (see Table 111) but possibly largely because it was leafy and thus the panicles received some protection from birds.

After harvest, the stubble was removed and the fields flooded again to give a ratoon crop. Growth of the ratoon crop was poor, but yields were more uniform and the order of merit of the varieties quite different. Whether this was the effect of ratooning, of the shorter growing period (two and a half months against four months for the first crop), or of absence of birds is not known, but the last may have been the most important factor. Yields at both harvests are shown in Table 111. The fields were flooded again after the second harvest, but regrowth was patchy and the second ratoon crop was not satisfactory.

TABLE 111. EOS2. IRRIGATED RICE VARIETY TRIAL

YIELDS OF FIRST AND RATOON CROP (LB. PER ACRE)

Variety	*First Crop*	*Ratoon Crop*
E1	2,918	1,452
Anbar Bau	1,922	1,286
Mekeo White	1,660	1,176
TP 1252	1,618	1,756
52/16.0.2.	1,328	1,881
Toen Toeng	844	1,438
Blue Bonnet	816	747
K1	259	1,355
Least significant difference—		
5 per cent.	1,119	512
1 per cent.	1,558	712

BULK RICE PRODUCTION

EOS1. Dry Land

In 1961-62, 75 acres was sown to nine varieties of rice for the purpose of supplying seed for distribution throughout the Territory. In 1962-63, 49 acres was sown.

The land was intensively cultivated during the four months prior to planting in late December, to control grass species. An initial deep ploughing turned the grass into the soil to a depth of 9 to 12 in. This was followed by a lighter ploughing, and then light cultivation at fortnightly intervals to destroy grass seedlings before they could flower. Final seed bed preparation was carried out with tandem offset disc harrows.

In 1961-62, good germination was followed by poor growth because of dry periods in February and early April, but good rain in late April and May brought a recovery and a reasonable harvest was taken. A single hand-weeding when the rice was 12 to 18 in. high gave adequate control of grassy weeds. However, *Pueraria* proved virtually uncontrollable. In early stages of crop growth it was kept down by two sprayings of 2,4-D but as the crop approached maturity spray equipment could not be taken into the field and *Pueraria* pulled down and smothered large sections of the crop. The vines also impeded harvesting. This plant should never be used as a cover crop preceding rice planting. About 17 acres of crop was lost because of weeds.

In 1962-63, rainfall was good, but the varieties Blue Bonnet, K1, and to some extent Mekeo White, suffered a heavy attack of cutworm in February. These completely stripped the rice plants and as a result weeds took control with resulting poor yields.

Areas harvested and yields are shown in Table 112. Figures reflect the weed condition in the different blocks rather than comparative performance of the varieties.

TABLE 112. EOS1. BULK RICE PRODUCTION, EPO

Variety	*1961–62*		*1962–63*	
	Area Harvested	*Yield*	*Area Harvested*	*Yield*
	Acres	lb. per Acre	Acres	lb. per Acre
Anbar Bau ..	½	772	1¾	1,760
E1	4	1,048	8	1,214
Toen Toeng ..	7	1,122	10	2,000
Blue Bonnet ..	7	1,901	8	177
Mekeo White ..	11	968	7	721
TP 1252 ..	11	1,514	..	..
52/16.0.2 ..	8	754	7	1,171
K1	10	739	7	614
Madang ..	¼	..	..	..

EOS4. Irrigated

First trials with irrigated rice plantings were made in 1961-62. As well as varietal trials, a block of about half an acre of variety K1 was grown for a study of the economics of mechanized, flood-irrigated rice culture in this locality. In 1962-63, three varieties were grown on a total area of 4 acres in a similar study.

In 1961-62, following levelling of the bays the soil was rolled to seal the bottom against water soakage, then harrowed and sown with a disc drill. The bay was watered to germinate the seed and when seedlings had reached 4 to 8 in. in height the field was weeded and then flooded. Weeding prior to flooding was necessary as several weed species, notably *Eleusine indica,* can survive flooding once they have become established. Following weeding and flooding, no further weed problem was encountered.

The water level was gradually raised to a maximum of 6 in., then drained a few days prior to harvesting. Sowing was carried out on 6th October 1961, and harvesting on 5th February 1962. The stubble was flooded on 14th February and a ratoon crop was harvested on 30th April.

The first crop was tall, vigorous, and healthy, though about a quarter of it lodged. This may have been a result of the heavy seeding rate of 150 lb. per acre. Bird damage to the panicles was extensive, causing loss estimated at 25 per cent. Maturity was even and the yield was 2,895 lb. per acre. The ratoon crop was poor, with a yield of only 760 lb. per acre. This may have resulted from a photo-period response forcing early flowering.

In 1962-63, the varieties E1, 52/16.0.2. and Toen Toeng were planted in bays of 1.3 acres each. Growth was good in two varieties, but the Toen Toeng bay was heavily infested with nutgrass and yield was badly affected. Both El and Toen Toeng lodged completely, but 52/16.0.2 showed very little lodging. Yields obtained were: El—4,123, 52/16.0.2 —2,029, and Toen Toeng—1,498 lb. per acre.

Overall results of these trials were very encouraging.

RATOON CROPPING

Observations in three different trials indicated that a first ratoon crop would mature two and a half months after harvest of the seed crop, independent of time of year or time to mature the seed crop. Further observations will be made.

MISCELLANEOUS

Abaca (Manila Hemp) (Musa textilis)

Growth in the clone x spacing trial has been generally unsatisfactory. Some of the plants were mature by June 1963, and the experiment will be assessed

more thoroughly in the near future. It seems probable that rainfall is too low at Epo for this crop to have any commercial possibilities.

Cashew Nut (Anacardium occidentale)

As described in earlier reports, difficulties were experienced in establishing this block and as a result the trees vary greatly in their stage of development. Survivors of the original planting are now in their fifth year and are reasonably productive. The crop shows some promise for this area.

Cotton (Gossypium hirsutum)

A variety x spacing x time of sowing trial, similar to that described at Bubia (BGH1), was planted in 1962, the three sowing dates being 20th February, 3rd April and 3rd May. The last planting was brought forward two weeks when good rains fell at that time, as it was feared that later planting may have failed. Germination was good, but a number of misses had to be replaced. Throughout the trial insect damage was severe, and frequent insecticidal treatment was necessary. Metasystox proved more effective than dieldrin or DDT. Unfortunately a herbicide spray was used in error for insecticide on one occasion, resulting in the loss of several plots of the first sowing. Results were therefore assessed on the second and third sowings only.

Average yields of the varieties over both sowings in pounds seed cotton per acre were—

Miller 43-9-0 Res.	1,126	Mexacala Res. . .	1,096
D and PL15 . .	1,118	Bobshaw 1-A . .	985
Empire . .	1,106	Lankart 57 . .	825

At both sowings, yields were highest at the closest spacing, averages over varieties (pounds seed cotton per acre) being: 3ft. 6in.—1,144; 4ft.—1,029; 4ft. 6in.—955.

Yields from the two sowings were of the same order.

A repeat of the same trial was planted in February to May 1963, to compare results in a different season. At June, the crop did not look promising as insect damage was severe, and boll shedding was occurring as a result of unsatisfactory rainfall distribution.

Castor Bean (Ricinus communis)

It was learnt that a number of the castor bean introductions from South Africa were true F_1 hybrids, and therefore, of course, did not breed true from seed. As importation of seed for each crop would involve excessive expense, these hybrids have been discarded from the testing programme and further work will be restricted to pure varieties. In any case, results showed little promise. A replicated variety trial planted in 1961 was completely defoliated by caterpillars (*Achaea janata*) and the plants died. A second planting in April 1962 gave very poor germination and poor growth, so that again the trial was unsuccessful. Experience has been that planting early in the wet season subjects the crop to insect attack which cannot be economically controlled, and by April conditions are too dry for planting. Late March would be the best planting date, but would still be risky.

Coffee (Coffea canephora)

*ECC*1. *Coffee Pruning Trial:* The five-acre block of Besoeki coffee planted in 1960 received its first pruning in January 1962. The block is a demonstration of multiple stem and Agobiada pruning. Shade was reduced substantially in March 1963, and good flowering followed.

*ECC*2. *Coffee Polyclonal Seed Garden:* This garden was well established and commencing to bear by June 1963.

Coconut (Cocos nucifera)

Of the 80 "Rotuma" nuts received from Fiji in December 1960, 38 germinated and 29 are well established in the field following transplanting in October 1961. Growth records were made every six months.

A small number of seedlings of Niu Leka x Malayan Dwarf progeny from Fiji were received in October 1962 and planted in the nursery.

Legumes

In addition to the legumes listed in the 1960-1961 Annual Report, *Cajanus cajan, Clitoria rubiginosa, Cassia mimosoides, Crotalaria alata, Crotalaria juncea* and *Indigofera arrecta* were planted for observation. Of all those under observation, the most promising for various purposes were *Cajanus cajan, Crotalaria juncea, Crotalaria alata, Dolichos lablab, Flemingia congesta, Indigofera suffruticosa, Phaseolus lathyroides,* and *Pueraria phaseoloides.* However, from seed of these harvested in 1962 and sown in March 1963, only the first two germinated in the field. Few of the plots of annuals in the field re-established themselves from seed.

Leucaena Hybrids

As reported in 1960-61, establishment from seed was poor because of dry weather. A further attempt to establish plots from cuttings was uneven, again because of low rainfall, and no comparison of vigour was possible.

Plate 16. Sisal observation plot at Epo. (*Photo: A. E. Charles*)

Oil Palm (Elaeis guineensis)

Seed of the following types was introduced from Malaya in 1960.

NG4625 .. Dura x Tenera
NG4626 .. Tenera x Tenera
NG4391 .. " Dumpy "—mutant of Dura

Seedlings were planted in the nursery in February—March 1960, and were transplanted to the field in January—February 1962. During the first twelve months in the field, losses amounted to 187, leaving 73 Dura x Tenera, 226 Tenera x Tenera and 650 Dumpy seedlings well established. Spacing was 32ft. triangle. Growth has been good, and by June 1963, flowering had commenced.

New seed of Tenera x Tenera and Dumpy has been obtained for filling the gaps in the stand.

Peanut (Arachis hypogaea)

Small observation plots were planted again in 1962 and 1963. In 1963, 60 varieties were planted, but three of these failed to germinate and others did not produce sufficient seed for replanting, so that the number retained after planting was reduced to 51. The four varieties showing greatest promise were planted in plots of 1/50 acre, and yielded at the following rates: NG4247—2,400; NG4555—1,830; NG4561—3,000; NG4566—2,420 lb. per acre. These four varieties will be increased further.

Sisal (Agave sisalana)

An observation plot was planted in June 1961, after a period of eleven months in the nursery. Plants were spaced in double rows at 3 ft. triangle, with 13 ft. between rows. Growth was satisfactory, and the first leaves were harvested in May 1963. Of 19,393 leaves harvested, 11,804 were discarded for being less than 24 in. in length. Those retained had an average fresh weight of 0.49 lb.

Sugar Cane (Saccharum officinarum)

In May 1962, the varieties Pindar, Trojan, Q50 and Q57 were introduced and planted in small plots for observation and increase. Only Q50 and Q57 established themselves. In May 1963, these two varieties were planted out in larger multiplication plots with irrigation.

Tobacco (Nicotiana tabacum)

Experimental work during the period gave only negative results. A variety x spacing trial planted in 1961 was discontinued when poor establishment rendered the spacings unreal. A fertilizer trial produced such variable results that no conclusions were possible. However, experience gained in these experiments was of practical value in improving production methods. A summary of planting and curing practice was given in the 1960-61 Annual

Report; some modifications recommended in the light of further experience are as follows—

(i) Shading the nursery beds is desirable for the first ten days, with shade retained during the heat of the day for a further five days. Frequent watering necessary when no shade is used can dislodge the seed and young seedlings.

(ii) An observation trial indicated that a thin covering (about $\frac{1}{8}$ in.) of sand over the seed at sowing greatly improved germination, and a light application of potassium and phosphorus fertilizer to the nursery beds was beneficial.

(iii) Treatments for control of frog-eye leaf spot should include soaking the seed for 15 minutes in 1:1000 solution of silver nitrate before sowing, fungicidal spraying of plants throughout growth, and rigid crop hygiene including the burning of all crop refuse.

(iv) Curing barns should have fires in external fireboxes with flues to convey heat and smoke into the drying chamber, rather than having the fire in the centre of the floor. A barn of dimensions 12 ft. x 12 ft., 15 ft. high, is adequate to handle production from one acre.

In May 1963, seed was sown for plots of the three varieties KY151, KY160 and Improved Yellow Mammoth. Transplanting took place on 19th June 1963, under favourable conditions, and one week later half the plots were fertilized with 200 lb. per acre of potassium sulphate. Leaf from these plots is to be compared to determine whether fertilizing has any influence on quality.

Pasture Grasses

Plots of the following grasses were planted in May or July 1962, for observation, and for multiplication of the more promising types for cattle pastures—

Cenchrus ciliaris (Buffel grass, Malopo strain).
Dichanthium annulatum
Digitaria Smutsii
Eragrostis chloromelas
E. curvula (American leafy strain)
Melinis minutiflora (Molasses grass)
Panicum coloratum (Bambatsi and Kabulala strains)
P. maximum (Guinea grass)
P. purpurascens (Para grass)
Paspalum urvillei
Pennisetum purpureum (Elephant grass)

Observations made up to June 1963, were that the two *Eragrostis* species and *Melinis minutiflora* could not survive under Epo conditions. *Cenchrus cilaris* and *Digitaria Smutsii* were growing well.

Weed Control

Nut grass (*Cyperus* sp.) caused increasing concern as a competitor with annual crops. Partial control appears to be of little value, since it increases so rapidly once control measures are relaxed after the planting of a crop. Various methods were tried for complete eradication of the weed.

(i) Deep ploughing to expose the bulbs in the dry season, followed by herbicide treatments throughout the wet season, at three-weekly intervals.

The method was quite unsuccessful as the large clods turned up by deep ploughing prevented desiccation of the bulbs and herbicide effects were only temporary.

(ii) Intensive surface cultivation during the dry season, followed by herbicide treatments.

A rotary hoe was used at two-weekly intervals throughout October, November and December 1961, thus powdering and completely drying the top 2 to $2\frac{1}{2}$ in. of soil. At the end of the period, germination was still uniform and complete over the entire area, although counts of viable bulbs showed some decrease. During December and January herbicide treatments were applied at two-weekly intervals. Herbicides tested were 2,4-D + T.C.A. in water, T.C.A. as granulated solid, T.C.A. in diesel distillate, T.C.A. in water, 2,4,5-TP in water, 2,4-D + 2,4,5-T in water. This list gives the order of effectiveness in reduction of the nut grass stand after application, but by June 1963, all except the first treatment had reverted to a full nut grass cover. Rates used in this treatment were 5 lb. a.i. per acre 2,4-D and 53 lb. a.i. per acre T.C.A. at each application.

None of these trials gives any lead towards an effective economic control.

RUBBER SECTION, BISIANUMU

Rubber experiment work for the Territory is carried out at Bisianumu adjacent to the Papuan Highlands Livestock Station in the Sogeri district, near Port Moresby. A description of the station was given in the 1959-60 Annual Report and a plan was shown in the 1960-61 Report. Rainfall data are shown in Appendix IV of this report.

Budwood Nurseries

The budwood nurseries are constantly expanding as more material is received and more than an acre was planted in the two years under review.

Twenty new clones were imported, bringing the total number of clones in the nurseries to 79 including two locally selected clones. *Calopogonium mucunoides* was established as a cover crop between the terraces of the western budwood nurseries.

Museum Plots

*BiHB*8. *Museum Plot No.* 1 : This contains 24 clones, with at least 60 trees per clone, planted between 1955 and 1957 and covering 8 acres.

Measurements in March 1963 showed 41 per cent. of the trees to be tappable, the best clones being KT1 with 77 per cent., ST8 with 77 per cent., and HC28 with 85 per cent. trees of tapping size.

*BiHB*9. *Museum Plot No.* 2 : A second Museum Plot containing 32 clones with a minimum of 60 trees per clone was established during January to May 1963 by bud grafting in the field. A most satisfactory establishment was obtained. The area is approximately 12 acres and spacing is 30 ft. x 8 ft. on contour lines.

BiHB6. Clonal Seed Garden

The first seed fall, approximately 2,000 seeds, was collected in 1962-63 from the better developed part of the seed garden which was planted in March to April 1957. Extensive drainage was carried out during the year and all grass and bush growth between the rubber lines was cut. General growth is satisfactory, but pink disease was more noticeable during 1962-63. Seed in commercial quantities is expected by 1965.

Clonal Yield Trials

*BiHB*1 : *Clonal Yield Trial No.* 1 : This trial, planted in March 1959, is progressing satisfactorily although insect attack caused some setback to growth in the fourth replicate. Differences in vigour between the clones are now noticeable, the local clone KT1 being outstanding. Differences between clones in susceptibility to various diseases are also showing up.

Early growth measurements of all trees in the trial were made in July 1962.

*BiHB*8. *Clonal Yield Trial No.* 2 : Three replications of this trial were planted in March 1960 and the fourth replication one year later. General progress in the whole of the trial is most satisfactory.

Early growth measurements were completed during August 1962. Vacant areas surrounding the trial were planted with bud grafts of various clones during 1962.

*BiHB*3. *Clonal Yield Trial No.* 3 : This trial was fully established by April 1962 and is now progressing normally. Pests and diseases, especially *Idiopsis* weevils, caused much trouble during the first year of establishment, but cause less reason for concern as the trees grow bigger. Two fertilizer applications during 1962-63 should also improve the vigour of the trees and increase their resistance to pests and diseases.

*BiHB*4 *and BiHB*5. *Yield Stimulant Trials No.* 1 *and No.* 2: These trials were brought to a conclusion in October 1962 when tapping was discontinued. Yield records for the whole period have been analysed by Mr. McIntyre and the results will be published in *The Papua and New Guinea Agricultural Journal*. Variability was high and thus the precision of the experiments proved low. The responses to stimulants were disappointing, being generally lower than has been reported from Malaya and other countries.

*BiHB*10. *Rubber Tapping Trial* : Preparations to commence a new tapping trial in the mature seedling rubber were completed by June 1963. Tapping operations will commence shortly.

Nurseries of Seedling Stocks

A total of 15,000 seedlings were established in nurseries during 1962 to serve as seedling stock for future bud-grafting operations.

Budgrafting Course

The annual budgrafting school in which plantation workers are trained in budgrafting techniques and practical planting methods was held in June 1962. A total of 21 trainees from 10 different plantations successfully completed this course. Another short school was conducted in February 1963.

Herbicide Trial

A trial was laid down in September 1962 to test the economics of using Simazine to maintain weed-free strips in the rubber lines. The herbicide was tested on slashed and clean-weeded strips with and without forking of the soil prior to application. Rates of application were 0, 7.5, 15.0 and 22.5 lb. per treated acre of Gesatop (Simazine 50W).

Evaluation after three months indicated that the herbicide was effective only after clean-weeding prior to application, and best weed kill was obtained at the highest rates. Subsequent maintenance should be possible with lower application rates, but it was very doubtful whether the method could compete in costs with the usual hand slashing.

Green Budding Experiment

Trials were started in December 1962 on green budding, i.e. budgrafting 2-8 month old seedling stock with buds from greenwood sticks of about the same age. The trials were of two methods, patch budding and shield budding, using budsticks of 5 clones. Results obtained were encouraging, with successes of 183 out of 360 (50.8 per cent.) for patch budding and 65 out of 360 (18 per cent.) for T budding. Further trials will be made later.

PLANT INDUSTRY CENTRE, BUBIA

Bubia is situated in the lower Markham Valley 9 miles from Lae, in the Morobe District. A description of the station was given in the 1959-60 Annual Report, and rainfall and sunshine data are shown in Appendix IV of this report.

COTTON (*Gossypium hirsutum*)

*BGH*1. *Variety x Spacing x Time of Sowing Trials*

In 1962, trials were put down at two localities in the Markham Valley to test Australian varieties of cotton under local conditions.

A trial of the same design was laid down in 1960 on Erap Station, but was not successful owing to atypical weather conditions and insect depredations. The cotton "bolted" and failed to produce mature bolls. In these two subsequent trials, particular attention was paid to planting dates to prevent a similar occurence.

Locality: Two areas were selected for the trial, both reasonably typical of their immediate environment. Their general climatic conditions were studied and planting dates were set accordingly.

(i) *Sasiang.* Although there were only four years' rainfall data, these indicated a fairly distinct dry period, as is essential for the ripening of the bolls. Sasiang is approximately 60 miles from Lae with a rainfall of 50-70 in. per annum, most of which falls in the "north-west" season of January, February and March. The selected block had an altitude of 650 feet.

(ii) *Erap.* A block was selected on the Erap Livestock Station as being representative of the area. Erap has an average annual rainfall of 40 to 60 in. per annum with a similar peak to Sasiang, but the incidence is much less reliable.

Soil Type: Both were light alluvial wash soils typical of the Markham Valley and were worked into a very fine seed bed for the cotton. The Erap soil was lighter than the Sasiang type and also had less depth of topsoil. Chemically, the soils were typical of the Markham Valley system in being slightly acid to neutral in pH, very high in calcium, magnesium, and phosphorus content with potassium possibly slightly deficient relative to the high calcium and magnesium.

The area selected at Sasiang had previously produced four crops of peanuts over a period of four years but had not been cropped for a period of eighteen months before the trial commenced and had reverted to kunai (*Imperata* sp.). The Erap area had previously grown rice some years ago.

Experimental Design: Plaid design with spacing in columns. Varieties also balanced in paired rows for each spacing at each sowing. The design allowed for 6 varieties, 3 spacings, 3 times of sowing and 3 replications.

Plot Size: Each plot consisted of four rows of cotton, 50 ft. long, the central two rows being harvested. The three replications covered almost 3 acres altogether.

Treatments

(i) Six varieties of cotton—

1. NG. 4352 . . "Lankart 57"
2. NG. 4353 . . "Empire"
3. NG. 4354 . . "Bobshaw 1-A"
4. NG. 4355 . . "Mexacala Res."
5. NG. 4356 . . "D. and P.L. 15"
6. NG. 4357 . . "Miller 43-9-0 Res."

(ii) Three spacings—

1. 3 ft. 6 in. between rows—1 ft. within rows
2. 4 ft. 0 in. between rows—1 ft. within rows
3. 4 ft. 6 in. between rows—1 ft. 6in. within rows

(iii) Three times of sowing—

1. Sasiang . . A. 13th February 1962
   B. 6th March 1962
   C. 10th April 1962
2. Erap . . A. 14th March 1962
   B. 13th April 1962
   C. Not sown owing to a severe dry period.

Plate 17. The cotton stainer, *Dysdercus cingulatus*, in a cotton boll. (*Photo: K. J. Blackburn*)

Rainfall

(i) *Sasiang*. From the first planting date till the final harvest—

Points

Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
590	911	723	645	77	335	548	136

(i.e. a total of 3,965 points over the growing period—the last bushes were harvested on the 28th September, 1962).

(ii) *Erap*. From the first planting date to the last harvest on the 18th October 1962.

Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
198	397	243	203	327	314	292	139

A total of 2,113 points over the trial period.

Pests and Diseases: A cover of Endrin was applied to both areas at least every fortnight to completely eliminate pest damage. Other insecticides used were Aldrin dust for aphids and white oil to combat cotton scale.

Insects were not a great problem as insecticide was applied regularly to the areas, but the "cotton stainer" *Dysdercus cingulatus* was not completely controlled. Aphids were troublesome at first and the rough bollworm, *Earias fabia*, caused the destruction of a small number of bushes. Other insect pests encountered were *Aphis gossypii*, cotton aphid; *Saissetia* sp., brown scale; and *Rhinoscapha consueta*, "kunai weevil". The brown scale was a troublesome pest on the older plants and was most difficult to control.

A severe attack of Cotton Rust, *Phakopsora gossypii*, occurred on both areas. This fungus is confined to the genus *Gossypium* and so can be controlled by burning the cotton bushes after picking.

Observations: A lack of lustre on the fibre was noted, probably as a result of the low light intensity experienced at this time of the year in the Valley. Although the cotton ripened in the driest part of the year, there was much cloud cover.

In sowing 1 at Sasiang, growth in different sections ranged from 1 to 2 ft. up to 5 to 6 ft. and maturity was uneven. It was found that this could be related to the C: N ratio in the soils.

In sowing 2 at Sasiang, growth was reasonably even, with the plants reaching a height of approximately 4 ft. This sowing averaged about four harvests per plot, with two peak harvests.

Plate 18. The third sowing in the cotton trial at Sasiang, at maturity. (*Photo: K. J. Blackburn*)

The bushes in Sowing 3 were very uniform in their growth pattern and did not exceed 3 ft. in height. Production, although lower than from Sowings 1 and 2, was confined to two or three harvests over a short period of approximately four weeks.

The greater uniformity of the later sowings may have been a result of a longer period of soil preparation and lower rainfall during the growing periods.

At Erap both sowings achieved a uniform height of 3½ ft. and there were three harvests over a period of two months. From the rainfall records, it will be seen that the Erap cotton only received a little more than half of the Sasiang rainfall and at one stage most of the bushes nearly died. Although they survived, they did not commence producing till five months from sowing, a month longer than at Sasiang.

Results: Analyses were made of yields for each sowing in each location and combined over sowings in each location. Also because of the sequence in dates of planting and apparent similarity of response, Sasiang 2 was grouped with Erap 1 and Sasiang 3 with Erap 2.

Spacing: There was a general trend to lower yields per acre with increased spacing (see Table 113 below.) The yield at 3 ft. 6 in. was consistently greater than at 4 ft. 6 in. over all sowings at both sites and differences were statistically significant.

TABLE 113. MARKHAM VALLEY COTTON TRIALS

YIELDS IN LB. SEED COTTON PER ACRE

Spacing	*Sasiang*				*Erap*			
	Sowing 1	*Sowing 2*	*Sowing 3*	*Mean*	*Sowing 1*	*Sowing 2*	*Mean*	*General Mean*
3 ft. 6 in. ..	1,543	1,333	1,114	1,330	1,159	1,176	1,168	1,249
4 ft. 0 in. ..	1,414	1,287	1,042	1,248	949	1,079	1,014	1,131
4 ft. 6 in. ..	1,487	1,132	997	1,205	993	997	995	1,100
Totals ..	4,444	3,752	3,153	..	3,101	3,252	..	..

TABLE 114. MARKHAM VALLEY COTTON TRIALS

YIELDS IN LB. SEED COTTON PER ACRE

Variety	*Sasiang*				*Erap*			*Means*	
	Sowing 1	*Sowing 2*	*Sowing 3*	*Mean*	*Sowing 1*	*Sowing 2*	*Mean*	*Sasiang 2 Erap 1*	*Sasiang 3 Erap 2*
Lankart 57 ..	1,192	1,131	711	1,011	861	911	886	996	811
Empire	1,422	1,120	1,063	1,202	983	1,194	1,089	1,052	1,129
Bobshaw 1–A ..	1,410	1,414	1,001	1,275	1,111	1,069	1,090	1,263	1,035
Mexacala Res. ..	1,622	1,311	1,104	1,346	1,099	1,016	1,058	1,205	1,060
D. & P.L. 15 ..	1,725	1,352	1,226	1,434	966	1,249	1,108	1,159	1,238
Miller 43-9-0 Res. ..	1,516	1,176	1,199	1,297	1,182	1,065	1,124	1,179	1,132
Least Significant Differences—									
5 per cent. ..	209	237	158	..	344	301	..	209	170
1 per cent. ..	281	320	213	..	464	405	..	282	229
0.1 per cent. ..	374	425	283	..	617	539	..	374	304

Varieties: At Sasiang, varietal effects and interactions with sowing date were significant at Sowings 1 and 3. At Erap, varietal effects were smaller and did not prove significant. However, yields in Sowings 1 and 2 showed a similar pattern to Sowings 2 and 3 at Sasiang (see Table 114).

Although these results are not clearly defined in all sowings, the varieties Mexacala Res., D. & P.L. 15, and Miller 43-9-0 Res. seem to be the superior types with D. & P.L. 15 having a slight yield advantage.

Cotton Assay: One bale of each variety of the Sasiang cotton was despatched to the Cotton Marketing Board, Whinstanes, Brisbane, to be commercially assessed (see Table 115).

TABLE 115. MARKHAM VALLEY COTTON TRIALS

COTTON QUALITY ASSESSMENTS

Grades, staple lengths, Micronaire and Pressley strength readings of the six varieties

Variety	*Grade*	*Length*	*Micron.*	*Pressley*
		in.		
Lankart 57 ..	gmls.*	31/32	4.8	65.5
Empire ..	gmls.	1	4.2	74.2
Bobshaw 1-A ..	gmls.	31/32	5.2	83.4
Mexacala Res. ..	gmls.	31/32	4.3	70.1
D and P.L. 15 ..	gmls.	1	4.1	73.8
Miller 43-9-0 Res.	gmls.	31/32	5.1	72.7

* Good middling, light spotted.

The staple of the Markham cotton is not long and this may reduce its value. Long staple cottons may tend to shorten in our environment due to photoperiodicity, as Mexacala grown in New South Wales achieved a staple length of $1\frac{1}{16}$ in. while in the Markham it was only $\frac{31}{32}$ in.

Discussion: From the yield figures, the cotton harvest compared well with Queensland production. However, a major problem is the delayed and continuous production and excessive vegetative growth of the bushes if the plants are sown too early in the season or receive more rain than necessary. In the Sasiang trial, although the third sowing did not produce as well as the first two sowings, the harvest was confined to a much narrower time period of two peak harvests which would be essential for mechanical harvesting of the crop. If handpicking were practised, this would not be such a problem, but prolonged production and excessive vegetative growth would still make weeding, insecticide applications and harvesting very much more difficult. A sacrifice in yield would have to be accepted in order to have a cotton stand that was easily manageable.

The actual precipitation received by each sowing on Sasiang and Erap was as follows—

			in.
(i) *Sasiang*	Sowing 1	.. ..	39.65
	Sowing 2	.. ..	31.22
	Sowing 3	.. ..	20.90
(ii) *Erap*	Sowing 1	.. ..	21.13
	Sowing 2	.. ..	16.58

All sowings in each trial ceased producing cotton at about the same time, the earlier sowings having a more prolonged harvesting period than the later ones.

Although the Erap cotton received much less rain than Sasiang cotton, the yields were still comparable to Sasiang Sowings 2 and 3. It would appear that a rainfall over the growing period of approximately

25 in. would be adequate, providing incidence tapered off at the harvesting period. It may be added that the Erap rainfall was atypical, being extremely low and quite irregular. The Sasiang rainfall pattern did not follow the general trend of the previous four years' recordings.

The Erap cotton also lacked the brightness of the Sasiang cotton and in some areas almost appeared grey. This was in some way connected with the severe setback when many plants wilted. The half-opened bolls collected moisture and discoloured the fibres while the plants were static.

PEANUT (*Arachis hypogaea*)

For some two years, yields of many commercial peanut areas in the Markham Valley have shown a marked decline. Three factors which probably contributed to this decline were:

(i) intensive cultivation, with removal of up to three peanut crops per year, without fertilizing or rotation,
(ii) weed competition, and
(iii) a common practice of using oil cull nuts for seed instead of selecting good quality kernels.

In an attempt to rectify the situation, fertilizer, herbicide and seed selection trials were planned.

FERTILIZER TRIALS

A trial was designed to compare responses to sulphur, lime and complete (NPK) fertilizer mixtures. Continued drought in the early months of 1963 prevented planting, but it is hoped that the trial will go out early in the next financial year.

BAH 3. HERBICIDE TRIALS

Pre-emergence Weed Control in White Spanish Type Peanuts

Weed control in peanut cultivation in the Markham Valley involves considerable expenditure. Inter-row weeding is carried out mechanically and makes less demands on time and labour than weeding within the rows, which has all been done by hand to date. Grassy weeds are more difficult to control than most broadleafed weeds with the exception of pigweed, *Portulaca oleracea,* which is an extremely troublesome pest of cultivation. Any measure which could reduce or eliminate hand weeding would therefore be very important to the peanut industry.

A trial was laid down at Munum Plantation in the Markham Valley to test four herbicides as pre-emergence applications. The treatments were—

(a) Control—no weeding.
(b) Weeds removed from between peanut rows (to simulate mechanical weeding).
(c) Weeds removed from between and within peanut rows (to simulate mechanical weeding plus hand weeding, i.e. normal practice).
(d) "Gesagard", Prometryne 50WP, at 1 lb. active ingredient per acre.
(e) "Tropotox", M.C.P.B. at 2 lb. acid equivalent per acre.
(f) "Shell Weedkiller D", 2,4-D amine, at 2 lb. acid equivalent per acre.
(g) "Shell Weedkiller M", M.C.P.A., at 0.6 lb. acid equivalent per acre.

Design was a randomized block with four replications. The herbicides were applied by means of pressure knapsack sprays in a band 18 in. wide over the peanut rows, two days after planting.

The recordings made were—

(i) Visual damage to emerging peanut seedlings.
(ii) Weed species controlled.
(iii) Visual weed score, based on the full plot.
(iv) Yields of peanut kernels, based on the central row of each plot.

Results

(i) At the rates applied, the herbicides did not visibly affect the emerging peanut seedlings.

(ii) 2,4-D Amine and M.C.P.B. controlled the following weed species—

Grasses—	Broadleaf Weeds—
Eleusine indica	*Portulaca oleracea*
Digitaria sp.	*Euphorbia geniculata*
Brachiaria reptans	*Physalis angulata*
	Tridax procumbens
	Cleome viscosa

(iii) A scale from 0 = weed free, to 10 = completely infested, was used in visually rating the various treatments. Ratings by two observers were made five weeks after the application of the herbicides.

The statistical analysis of the weed scores showed differences significant at the 1% level. Analysis of the transformed means of the treatments showed that at the 5% level, M.C.P.B., 2,4-D and M.C.P.A. treatments differed significantly from the controls, while M.C.P.B. and 2,4-D differed significantly from the Prometryne treatment. Prometryne did not differ significantly from the controls.

The 2,4-D amine and M.C.P.B. both gave effective weed control up to 12 weeks after application.

(iv) Yield of peanut kernels. Analysis failed to indicate a significant difference between treatments.

Discussion: Although the weed score analysis showed a marked difference in weed populations of the plots, these differences were not evident in the final yield analysis. The heavy weed population in the control plots did not significantly reduce the yield compared with the weeded plots. This can be attributed, at least in part, to the ideal growing conditions during the period of the experiment. It is suggested that under the conditions of the experiment the weeds were not competing severely with the peanuts. Weed control is still essential, however, since weeds interfere with harvesting operations.

Herbicide use would aim only at reducing costs of hand weeding within the rows. Mechanical inter-row cultivation contributes only one third of the costs of weeding and also probably improves the environment in the region of nut formation. Therefore, overall weed control by herbicides would not be recommended. Pre-emergence sprays, applied to bands 18 in. wide over the peanut rows controlled weeds in the present trial, and under similar conditions could be expected to eliminate two hand weedings, and in a wet season, probably three. Taking costs into account this could mean a saving of approximately £2 per acre for the farmer.

Narakapor—Herbicide Application

Following the encouraging results of the trial at Munum, it was decided to lay down another trial using different rates of 2,4-D. This was completed on 19th November, 1962, on Narakapor Plantation, and consisted of one replication of 1 lb., 2 lb. and 3 lb. active ingredient of 2,4-D per acre. At the same time an area of approximately 7 acres of peanuts adjacent to the experimental block was treated with 2 lb. a.i/acre of 2,4-D, using a boom spray constructed at Bubia. On the trial as well as the commercial application, the weedicide was applied on top of the peanut row in a band 18 in. wide, two days after sowing.

Unfortunately, no effects were obtained although every precaution was taken in the herbicide application. The soil was very dry at the time of application and this was most likely the important factor in the failure of the herbicide to act on the emerging weed seedlings. For pre-emergent action, the soil must have sufficient moisture to enable the herbicide to form a film.

At about the same time, the management of Munum Plantation also used a 2,4-D herbicide application but with mediocre results. In this case, heavy rain after application was thought to have upset the herbicide action by washing the 2,4-D away from the roots of the developing weed seedlings.

In both cases, 2,4-D amine was used as it is readily soluble in hard water, although water softener was added in the Narakapor trial.

In the light of all the results obtained, it appears that pre-emergence applications of 2,4-D are not satisfactory for the Markham Valley environment, for a number of reasons, but mainly because—

(i) The high soil temperatures experienced in the Valley, with lack of rain, lead to an accelerated breakdown of the herbicide.

(ii) Pre-emergence herbicides should be applied to moist soils for the herbicide film to be formed. This is not always possible in the Valley as peanuts are planted, and do germinate, on reasonably dry soil.

(iii) The seed bed should be worked very finely for maximum effect, and this would increase planting costs.

Further herbicide trials will therefore place the emphasis on post-emergence treatments.

SELECTION PROGRAMME

Random selections of kernels were made on four properties spread over the peanut producing area. Some 200 lb. of kernels obtained were then hand selected for even size and shape, and the selected seed was treated and planted.

It was estimated that at the normal planting density in the Markham Valley each bush must produce 15 whole kernels to give a yield of 1,000 lb. kernels per acre. Accordingly, after initial selection on general vigour and even growth, all plants yielding less than 15 kernels were discarded and the remainder were classified into ten classes on the basis of numbers of kernels produced. The best bush produced 120 whole, sound kernels. The resulting seed will be planted for a further round of selection.

To compare peanut seed from outside the Markham Valley, a bag of White Spanish seed was obtained from Kapogere and will be planted alongside the local selections.

Irradiation: A sample of seed from the original collection was subjected to X-ray treatment at intensities ranging from 25 to 100 rontgens. The seed was then planted, but only one plant showed any apparent change. This plant, from the 100 R. treatment, produced kernels more than twice the normal size and fell into the 50-59 kernel yield range.

MISCELLANEOUS

Castor Bean (Ricinus communis)

In a trial of introduced castor-bean varieties at Bubia in 1960-61 (see 1960-61 Annual Report) the results were poor because of excessive rainfall and insect

attack. On the other hand, quality was satisfactory with oil contents averaging about 53 per cent. while 48 to 50 per cent. is regarded as commercially satisfactory. A new trial was therefore laid down in the drier climate of Erap in the Markham Valley.

The trial compared eight introduced varieties, grouped as six small-growing and two tall types. Spacings of 3 ft. x 2 ft., 3 ft. x 3 ft. and 3 ft. x 4 ft. were used with the small types and 6 ft. x 3 ft., 6 ft. x 6 ft. and 3 ft. x 4 ft. with the tall types. Four seeds were planted at each point with the most vigorous plant only retained after germination. One variety gave very poor germination and hence poor establishment and it had to be omitted from analyses.

The trial was planted in August 1962, and harvesting continued until April 1963. January and February were very dry and this, combined with insect damage, caused complete defoliation of many plants. Six harvests were made at two-weekly intervals to cover the highly variable maturity. Much of this variation in maturity could be attributed to the poor rainfall.

A most notable feature of the trial was extreme variability within many of the varieties under test. It was subsequently learnt that some of the original introductions had been F_1 hybrids, and as seed used in the trial was at least second generation, it was segregating. Some of the non-hybrid types also showed considerable variation, indicating probably impure seed.

Results indicated a general tendency to higher yields at closer spacings, but the effect was not statistically significant. There were highly significant differences between varieties, the best being NG4388 " VC53 " and NG5230 " Gnomda ", of which the latter was progeny of hybrid seed although field observation indicated the former as being more variable at this planting. The two tall varieties, NG4369 " S367 " and NG4370 " R63 " both performed comparatively well, when allowance was made for very poor establishment in the latter. Yields of the best varieties were of the order of 1,000 lb. per acre, which would probably be commercially acceptable.

Sisal (Agave sisalana)

Sisal holding blocks are being maintained at Erap, Sangan, Marilumi and Sum-Sum.

One indigenous grower is planting a six-acre block of good grassland to produce fibre for local sale. Planting material is being raised in the Bubia nursery.

One aspect of the sisal work in the District is that almost every village in the Markham Valley and Morobe Highlands now has some plantings of sisal. Leaves are stripped by the women who extract the fibre by drawing the leaves through a split bamboo. This produces a comparatively clean white fibre, which has largely supplanted indigenous fibre for village production of string, rope, string bags, nets, etc.

Cacao

BTC.1. *Minor Element Spraying Trial, Suambu Plantation:* Treatments aimed at controlling die-back were described in the 1960-61 Annual Report. These have been continued, though some variation in the programme was caused at times by wet weather. Yield records have been maintained since the first bearing in October, 1961, but many trees are not yet bearing and no clear responses are evident. Die-back is present in all treatments and there is nothing to indicate that any treatment has been at all effective in its control.

Pasture Investigations

Pasture species introduced and planted in observation plots are listed in Table 116.

TABLE 116. PASTURE SPECIES INTRODUCED TO BUBIA 1961–63

Number	*Name*	*Source*
NG.5193 ..	*Desmodium uncinatum*	C.S.I.R.O.
NG.5194 ..	*Desmodium intortum*	C.S.I.R.O.
NG.5195 ..	*Paspalum plicatulum* (CPI.118266)	C.S.I.R.O.
NG.5196 ..	*Setaria sphacelata*	C.S.I.R.O.
NG.5190 ..	*Melinis minutiflora* (Molasses grass, Kitale Commercial) ..	Kenya
NG.5191 ..	*M. minutiflora* (Molasses grass, Chinia River)	Kenya
NG.5192 ..	*M. minutiflora* (Molasses grass, Mbooni Hill)	Kenya
NG.4887 ..	*Centrosema pubescens*	Malaya
NG.4969 ..	*Sorghum almum*	C.S.I.R.O.
NG.5243 ..	*Glycine javanica* (Tinaroo glycine)	C.S.I.R.O.

Of these introductions, the two species of *Desmodium* failed to survive.

In the 1960-61 Annual Report, Siratro (*Phaseolus atropurpureus*) was reported as showing considerable promise. In further observations and tests at different sites, Siratro has shown good vigour but has set seed only very lightly so that seed cost would be very high.

A study was made at Bubia of growth and nutritional value of *Rottboellia exaltata*, a grass which has shown some promise in the Port Moresby area,

particularly in regard to the high protein content of young growth. At Bubia, the nutritional value was good, but the grass failed to make satisfactory regrowth after cutting back unless the soil was disturbed frequently.

A small plot of lucerne (Yates Broadleaf) was planted in November 1961, to study its possibilities as a green feed. Growth was promising and in six cuts at intervals of eight weeks, production of dry matter was estimated at 3.8 tons per acre. A larger plot was planted in November 1962 with a plot of *Phaseolus lathyroides* alongside for comparison. This planting of lucerne suffered severely from *Sclerotium rolfsii* rot and in June 1963, it was discarded. The *Phaseolus lathyroides* made good growth and was highly productive, but it also was removed in June 1963, as it showed "little leaf" disease. The comparison showed that *P. lathyroides* produced greater quantities of dry matter and protein than did lucerne under Bubia conditions.

Vanilla (Vanilla planifolia)

Commercial assessment of the first sample of beans harvested indicated that this sample was not up to the standard of Tahitian vanilla and would be valued only at one-third the price.

Further work on preparation of the beans will be made when possible, but a more pressing problem is that of inducing flowering and fruit setting. First flowering of the vines occurred after some plants had been accidentally cut. At the time it was thought that this had been a removal of the growing extremities of the vines but it is now considered likely that the roots had been severed. Further studies have indicated that under local high rainfall conditions, the tendency is for vigorous vegative growth, with flowering induced only if sections of vine are completely disconnected from the soil. Examination of vines flowering in 1963 showed evidence of moisture stress and it was found that in all cases the flowering sections were completely severed at some point from their roots. In the dry conditions prevailing, it appeared unlikely that any beans would mature, but under more favourable conditions, beans might mature before the section of vine died. Trials have been commenced to find out whether deliberately severed sections, 15 to 20 ft. in length, will flower and produce beans. Other studies will be made with hormonal treatments.

Propagation: Pieces of vine, 1, 2, and 3 nodes in length were taken and placed in a propagation bin, without any additional treatment. All were found to be well supplied with roots at fourteen days and buds became evident at 21 days. Thus propagation is simple and rapid.

Rice (Oryza sativa)

Eight varieties of paddy rice were planted in a typical Markham swamp area to study their performance under local conditions. The varieties proved to be impure and therefore unsatisfactory for comparison, but useful observations were made on growth and planting techniques.

Nursery: Seed was sown in wet soil and the nursery flooded after germination, the water level being raised as the seedlings grew. Two types of algae were abundant, but did not prove harmful. Water temperatures over the 43 days in the nursery averaged—

9 a.m.		*12 noon*		*3 p.m.*	
In	*Out*	*In*	*Out*	*In*	*Out*
72°F.	80°F.	85°F.	90°F.	90°F.	98°F.

On three occasions the water reached 100 degrees Fahrenheit at the outlet, but there was no evidence of damage to the seedlings. During the period, daily sunshine averaged 5 hours 43 minutes.

Transplanting: Although 40 days is a general recommendation for transplanting, growth appeared excessive under local conditions. Stooling was well advanced, leaf trimming was necessary and recovery after transplanting was slow. In later work, seedlings were transplanted at 27 days and recovery occurred within three to five days. The rice was planted by the traditional method of forcing seedlings into the soft mud at a spacing of approximately 10 in. x 10 in.

Paddy Preparation: The land was not clean cleared and masses of plant debris were incorporated in the blue-grey pug soil. The area was heavily saturated with swamp water and the soil was puddled by hand tools, preparation being deliberately kept to a minimum.

Growth: Vegetative growth was very vigorous and it appeared that rice would do well under controlled paddy conditions on swamp soils.

Selection: From the material planted, 24 different types were separated out and a single head of each retained for multiplication.

Plate 19. An aerial view of part of Garaina Experimental Tea Plantation, showing the factory. In the foreground are unpruned, widely spaced seed-bearers. Plucking areas are visible at left centre and top. (*Photo: D.I.E.S.*)

Plate 20. Women plucking tea at Garaina. (*Photo: D.I.E.S.*)

EXPERIMENTAL TEA PLANTATION, GARAINA

This pilot commercial tea plantation is located in the Waria Valley in the Morobe District, at an altitude of 2,000 feet. A description of the station was given in the 1959-1960 Annual Report, and rainfall data are shown in Appendix IV of this report. Plates 19 and 20 illustrate the layout of the plantation and factory and show pluckers at work.

With completion of the factory in 1962-63, the plantation commenced producing tea in quantity. Early results indicated that there are good prospects for commercial production in the Territory.

FIELD CULTURE

Planting

During 1962 nurseries were laid down carrying about 25,000 plants. This completed requirements of supplies for the 350-acre planted area.

Spacing

Experience at Garaina has indicated that the double hedge spacing used for the bulk of the planting is not ideal. It shows no advantage over a single hedge, and renders weeding more difficult, while soil tends to be thrown away from the centre of the row in weeding operations. A spacing of 5 ft. x 3 ft. looks more suitable for Garaina conditions, and for the highlands 5 ft. x 2½ ft. is recommended.

Nutrition

As stated in previous reports, a regular programme of fertilizing with sulphate of ammonia had been commenced following clear response in colour and growth with this fertilizer. Trials conducted by the Senior Chemist have indicated that the response is probably mainly due to sulphur rather than nitrogen as there is an acute sulphur deficiency in Garaina soils. In control plots in the trials (the only parts of the plantation that have never received any fertilizer containing sulphur), the bushes are declining rapidly. The effect of the deficiency is especially evident in a failure of many bushes to come away again after pruning. More details are given in the report of the Agricultural Chemistry Section.

Planting Material

Work was commenced on thinning out a 20-acre block as a seed bearing area, leaving bushes spaced at 15 ft. intervals. This is additional to an existing 30-acre seed area. Up to June 1963, 1 ton of seed had been supplied to growers.

From the area being plucked, 50 bushes were selected as showing outstanding qualities. A nursery was being prepared for vegetative propagation of these selections.

PRODUCTION

Plucking

The women from neighbouring villages have been employed as pluckers and have shown considerable aptitude and enthusiasm for the work. The daily plucking average increased from 24 lb. green leaf in March 1963 to 41 lb. in June 1963. Work quality was also very satisfactory.

Tea Factory

Construction work on the factory was completed early in 1962 and drying trials were conducted. The factory was offically opened by His Honour the Administrator, Sir Donald Cleland, on 28th August 1962.

A number of technical difficulties had to be ironed out in the early stages, but by the end of the year all phases of processing were operating smoothly. A total of 35,525 lb. of made tea was produced in the ten-month period from the opening of the factory.

Capacity of the machinery initially installed proved to be about 1,200 lb. green leaf daily and this quantity was being plucked from about 55 acres. The factory building was designed to permit expansion and further machinery will be installed to increase its capacity.

Tests on early samples gave encouraging results and a trial shipment to Melbourne brought good prices.

EXPERIMENTAL PLOTS, YAMBI

Yambi is situated on the plains of the Sepik River in the Sepik District, and is typical of some millions of acres of land of low fertility, the economic potential of which is being investigated. A description of the station was given in the 1959-60 Annual Report, but it should be noted that the annual rainfall quoted there was probably not correct. Subsequent records indicate that the average is between 80 and 90 in. per annum.

Minor Element Trial

In the omission method trial described in the 1959-60 Annual Report it was observed that there was apparently some deficiency of minor elements, but the trial was not designed to determine which element or elements were involved. In June 1962, a diagnostic trial was laid down to study the elements copper, zinc, molybdenum, boron, manganese, magnesium, and iron, over a basal dressing of monocalcium phosphate and potassium sulphate. The trial design was a half replicate of 2^7 factorial. The indicator plant was maize.

Heavy rains during the course of growth caused some physical damage to the plots and possibly leached away some fertilizer. However, quite early in

the growth of the crop it was evident that there were pronounced differences between treatments. At harvest, records were made of the weight of cobs, weights of stalks plus leaves, and height of plants. Analysis of the different measures showed significant effects, but there was some divergence between them in the elements implicated. Magnesium response was prominent in height and in stalk and leaf weights, but not in cob-weights. Molybdenum and manganese showed up in the cob weights and heights, and iron showed up in cob weights. To examine the deficiencies further a trial will be laid down in 1963 to study these four elements again.

Cotton

Four plots of cotton were planted in June 1962. These comprised ½ acre of variety "Empire" with full fertilizer, at Yambi; ¼ acre of variety "Lankart", half with lime and half with no fertilizer, at Yambi; and two ¼ acre plots of varieties "Bobshaw" and "Mexacala" with full fertilizer at villages 3 miles and 7 miles from Yambi. The cotton germinated and grew well initially, but after a few weeks insect damage was severe. Continuous rains impeded insect control and caused virtually complete failure of the crop after flowering. Fungi attacked the developing bolls and a large proportion ceased to develop, partially opened bolls exposing a blackened mass of immature fibres. At harvest, the ½ acre block at Yambi produced only 52 lb. of clean seed cotton from two pickings.

A clear response to liming was evident in plant growth.

Rice

A half acre plot of rice was sown in November 1961, with superphosphate, muriate of potash, and mixed minor element fertilizers. The crop was to be grown under flood irrigation, but because of unseasonably dry weather the bays periodically dried out. Initial growth was good, but on drying out the rice was heavily attacked by fungi, identified as *Helminthosporium oryzae* and *Ramularia oryzae*. The crop flowered in 85 days and matured in 141 days. Yields were poor, amounting to only 383 lb. from the half acre plot.

Pastures

In 1960 and 1961 three paddocks each of 6 acres were sown to introduced pasture species, with light dressings of complete fertilizer, for observations on performance of the different species and to establish reserve pastures for later cattle introductions. The following notes were made on pasture performance:

Molasses Grass: generally fair growth, but only really satisfactory when planted in association with *Centrosema.*

Buffel Grass: poor growth.

Guinea Grass: initially fairly good, but subsequently made poor growth unless heavily fertilized.

Para Grass: this was planted from cuttings in December 1962, and up to June 1963, showed promise of being superior to the earlier introduced grasses.

Leucaena glauca: very poor growth.

Pueraria: good growth initially, but subsequently showed deficiency symptoms and finally defoliated.

Centrosema pubescens: would not tolerate wet areas, but where drainage was satisfactory it made good growth and re-established well from self-seeding.

Four paddocks of 6 acres and another of 20 acres of natural pastures were fenced for trials of cattle grazing. A further 30 acres was being fenced at June 1963, to increase the pasture reserves. Commencing in December 1962, these paddocks were mowed regularly to bring away more succulent growth. Some difficulty was experienced in this operation because of the "pot-hole" condition of much of the area which was very hard on machinery

In January 1963, nine ¼ Brahman-Angus steers, 9-10 months in age, were transferred from the Moitaka Livestock Station to Yambi. These were held on natural pastures with salt licks initially, but will be divided up for comparison of three treatments—

(i) natural pasture, topdressed with fertilizer, mineral lick *ad lib.*
(ii) natural pasture, no fertilizer, mineral lick *ad lib.*
(iii) natural pasture, no fertilizer, salt lick.

The salt lick will contain sodium chloride only, while the mineral lick will contain a variety of minerals.

Forest Trees

Seed of balsa and teak were planted in the nursery in December 1961, and the balsa was planted out shortly after while the teak remained in the nursery for a longer period. Balsa made fair progress when fertilized, but did not do well without fertilizer. *Eucalyptus deglupta* seedlings planted in 1961 grew well and were 20 ft. tall at eighteen months of age.

PLANT INTRODUCTION AND QUARANTINE

PLANT INTRODUCTION AND EXCHANGE

Contact was maintained with Research Institutes, Botanic Gardens and Departments of Agriculture in various parts of the world, seed usually being obtained on an exchange basis. An inter-governmental agreement for the exchange of plant material between Australia (on behalf of Papua and New Guinea) and Malaya came into force in November

1962. This agreement makes possible the continued supply of rubber budwood of new clones by the Rubber Research Institute of Malaya, and also opens the way for securing from the Department of Agriculture other plant material, such as fruit trees, nutmeg, cloves and bamboo.

Introductions tended to be somewhat lower in the two years than previously (see Tables 117 and 118), although the number of introductions for 1961-62 appears large because of the large numbers of wheat varieties introduced. The aim has been to restrict introductions to material which could be immediately used by the research workers for a specific project, as the Department has not the resources for large scale testing of a wide variety of introductions.

TABLE 117. CLASSIFIED LIST OF PLANT INTRODUCTIONS, 1961–63

Type of Plant	*1961–62*	*1962–63*	*1961–63*
Cereals—			
Sorghum	3	1	161
Wheat	157	..	
Pasture and Forage Crops—			
Pasture grasses	8	5	30
Pasture legumes and cover crops	5	12	
Oil Crops—			
Castor bean	6	4	22
Sesame	..	8	
Sunflower	..	4	
Fibres—			
Cotton	2	10	14
Kenaf	..	2	
Stimulants and Spices—			
Cacao	30	64	129
Coffee	10	7	
Ginseng	1	1	
Nutmeg	1	1	
Sugar beet	7	3	
Sugar cane	..	4	
Rubber	28	2	30
Fruits	5	28	33
Vegetables	17	25	42
Ornamentals	2	7	9
Drugs, Insecticides and Essential Oils—			
Derris	..	2	8
Duboisia	..	4	
Lemon grass	..	2	
Reagent Plants	10	..	10
Miscellaneous	4	8	12
Total	296	204	500
For quarantine observation	338	82	420

TABLE 118. PLANT INTRODUCTIONS 1961–63

COUNTRIES OF ORIGIN

Source	*1961–62*	*1962–63*	*1961–63*
America—			
United States of America	122	36	248
Costa Rica	1	..	
Puerto Rico	..	1	
Trinidad	29	59	
Pacific Region—			
Fiji	1	..	24
Hawaii	1	..	
New Zealand	9	10	
West New Guinea	..	3	
Asia—			
Ceylon	2	..	60
Hong Kong	1	..	
India	7	2	
Indonesia	..	1	
Japan	..	1	
Malaya	28	2	
North Borneo	..	1	
Philippines	3	2	
Singapore	4	6	
Africa—			
Kenya	3	1	21
South Africa	6	9	
Southern Rhodesia	..	1	
Zanzibar	..	1	
Europe—			
England	4	..	19
Italy	3	3	
Portugal	9	..	
Australia—			
C.S.I.R.O.	10	17	128
Department of Agriculture—			
New South Wales	..	10	
Queensland	7	12	
South Australia	2	..	
Tasmania	..	1	
Western Australia	..	1	
University of Sydney	39	..	
Commercial	5	24	
Total	296	204	500
For quarantine observation	338	82	420

Seeds forwarded to other countries during the two years included orchids to Ceylon; a collection of papaw (papaya) varieties to Puerto Rico; coconut to American Samoa; indigenous *Citrus* species to the United States; okari nut (*Terminalia kaernbachii*) to Indonesia; sisal and sweet potato to Australia (Northern Territory); rice varieties to U.S.A., Japan, Pakistan, Philippines, Ceylon, Malaya and Taiwan for testing for resistance to blast (*Pyricularia oryzae*); sweet potato to Angola; legume cover crop species to South Africa; rice seed to the British

Solomon Islands Protectorate; wild rice seed to India for breeding work; and numerous other small consignments.

Cacao

As reported in 1960-61, steps were taken to secure material of the Upper Amazonian strains through growth of clones at Canberra and by introduction from Trinidad. Both approaches brought in a good supply of material for breeding purposes in 1962-63.

The clones Na 32 and Pa 35 supplied by the Department of Agriculture of Fiji and grown on our behalf in the glasshouse in Canberra were hand-pollinated when they commenced flowering. A number of pods were set and seed was forwarded to the Territory, after which the parents were destroyed. A large number of seedlings was raised at Laloki for forwarding to Keravat after quarantine observation.

The seed introduced from Trinidad resulted from hand-pollinations carried out by officers of the Department while studying there. Some technical difficulties were encountered in transport of the seed, and germination of early consignments was poor. Trials were carried out with four treatments:

(i) unwashed, packed in charcoal—
  (a) in polythene bag
  (b) in thermos flask
(ii) washed, treated with 1 per cent. Aretan—
  (a) in polythene bag
  (b) in thermos flask

The fourth treatment proved most satisfactory and was adopted for later consignments. There were still losses due to breakage of the thermos and subsequent chilling en route, but where the thermos survived intact germination was close to 100 per cent.

The material introduced in this way consisted of crosses within and between the Scavina, Nanay, Parinari and Iquitos Mixed Clones families. Testas of the seeds were removed prior to planting, and after quarantine observation at Laloki the seedlings were transferred to Keravat.

Another cacao introduction consisted of six pods of West African Amelonado from Malaya.

Coffee

Introduction of varieties resistant to coffee rust (*Hemileia vastatrix*) continued, and also of differential varieties for recognition of various rust strains. The material included nine selections from the Centro de Investigacao das Ferrugens do Cafeeiro at Oeiras, Portugal, which is the leading world centre for research on coffee rust. The introductions are not commercial varieties, but would serve as a source of resistance genes in the event of introduction of the disease. *Coffea racemosa*, which was introduced earlier as a reactor susceptible to all rust races, failed to grow satisfactorily in the highlands. Enquiry showed that its natural habitat is the dry savannah of East Africa, and plants were therefore returned to Laloki to be maintained there.

Frost Tolerant Food Crops

Concern has been felt for some years over periodic frost damage to sweet potato grown at high altitudes, particularly in the Western Highlands, resulting in occasional local famines. Although the less susceptible Irish potato (*Solanum tuberosum*) would serve nutritionally as a satisfactory substitute, it would not necessarily be acceptable to the people. Other plants introduced for testing have included ten sweet potato varieties from New Zealand originally collected by Dr. D. E. Yen at high altitudes in Bolivia, Ecuador and Peru. From an initial introduction in 1961, only one variety survived, but in 1962 a second introduction was successful in establishing the ten varieties. After quarantine observation at Laloki, cuttings were sent to Aiyura and Mount Hagen for observation and multiplication prior to testing at high altitudes.

Sugar beet varieties from England and Italy were also introduced, and turnips, swedes and tick beans. Although not acceptable as staple foods, some of these could serve as useful reserves for famine periods.

Wheat varieties were introduced and planted at Aiyura, and notes on their performance are given under the report for that station. One variety of wheat originating from the Congo in earlier years was already known to produce fairly well under highland conditions. The main new introduction was a large collection of varieties grown within five degrees of the equator, supplied by the United States Department of Agriculture from their World Collection of Small Grains.

Rubber

The introduction of additional clones to build up the collection at Bisianumu continued, and included some of the latest clones released for planting overseas. Most were obtained by purchasing a few yards of budwood from the proprietors, the Department acting as the local distributing agent for selling budwood on a royalty basis. The group also included two clones from the Rubber Research Institute of Ceylon and one clone (AVROS 427) released by Indonesia in exchange for cacao budwood of the Keravat clone K20. Clone PB49, obtained from Prang Besar Estate in Malaya, is not for general sale even in Malaya, though it has been used as a seed parent in some seed gardens. It was obtained on the special condition that it would not be released from Departmental control without Prang Besar Estate's consent.

Rubber seed was also imported in quantity for Extension projects in the Central and Gulf Districts. One hundred thousand Gough Garden No. 1 polyclonal seeds were purchased from Prang Besar Estate. This is the most advanced clonal seed available at present.

Spices

One thousand nutmeg seedlings (*Myristica fragrans*) were secured from the nurseries at Fak-Fak in West New Guinea prior to the termination of the Netherlands' administration. Five hundred were established in a future seed production area at Bubia, Lae, while approximately 100 trees each were sent for station planting at Oriomo, Murua, Popondetta, Kavieng and Samarai. Additional nutmeg trees were received for distribution on behalf of the South Pacific Commission and were sent to Fiji, Samoa, Tahiti, New Hebrides, New Caledonia, British Solomon Islands and the American Trust Territory of the Pacific. All plants arrived at their destination in good condition.

Fruit Trees

Some rambutans and durians were obtained from the nurseries at Fak-Fak. Introductions were also made of nine avocado and eight mango varieties obtainable from commercial nurseries in Australia for the planting of basic plots at a number of agricultural stations. Mango trees raised at Laloki from seed introduced from Queensland were also distributed to a number of centres.

Tomato

The variety "Platillo", reputedly resistant to bacterial wilt, was imported from Puerto Rico and after quarantine observation made available to two growers in Port Moresby who had experienced difficulty with bacterial wilt in hydroponic cultures. It appeared to have field resistance to the disease but was unsatisfactory commercially, giving low yield, uneven maturity and a deeply segmented fruit. Seed was forwarded to C.S.I.R.O. in Australia for possible use in breeding work.

Lemon Grass

Work at Bubia indicated that the lemon grass commonly grown in the Territory contains a relatively small percentage of essential oils so that extraction is uneconomic. Two introductions were made from India, *Cymbopogon flexuosus* (producing lemon grass oil) and *C. nardus* (citronella oil). Both are very vigorous and produce seed profusely and should be useful in the event of interest re-emerging in the extraction of essential oils.

Lima Beans

There have been occasional cases of cyanide poisoning, mainly among children, caused by Lima beans (*Phaseolus lunatus*). It has not been established whether these have resulted from planting of wild varieties, by poisonous strains developing in cultivated varieties, or by some environmental factor causing toxicity to develop. It is clear, however, that children at least are not able to distinguish poisonous from non-poisonous strains. The supposed correlation between colour and toxicity does not hold, as white beans have been found which give a strong cyanide reaction and some coloured or mottled beans were free. In order to distribute seed of known cultivated varieties unlikely to be poisonous, several horticultural varieties were introduced and multiplied for distribution.

Sorghum

The variety "Belleza", originally introduced from Guatemala, and found to be most suitable under local conditions, had been lost as a result of cross-pollination with broom millet. A fresh introduction was made from Turrialba, Costa Rica.

Bamboo

Earlier efforts at bamboo introductions gave poor survival because of chilling of the planting material in high flying aircraft and desiccation during transport. A further consignment sent by air from Singapore gave 50 per cent. survival.

Derris

As a result of the development of resistance in insects to synthetic insecticides and publicity on their residual toxicity, there could be a revived market for natural insecticides. Planting material was therefore obtained of *Derris elliptica* with an established high rotenone content, from North Borneo.

Oil Seeds

Three castor bean and eight sesame varieties were received from the United States Department of Agriculture. The sesame was intended for trial in the Markham Valley. Several were found to be indehiscent—the first time that complete indehiscence had been observed in sesame varieties.

Lentils

A series of lentil selections was obtained from Tasmania for trial in the highlands. To date lentils have failed to grow satisfactorily under Territory

conditions—presumably growth is inhibited by photoperiodism, yet it would be a valuable, protein-rich pulse if a suitable variety could be found.

Pastures

Grass introductions during the year included *Cenchrus setigerus* and *Dicanthium aristatum* var. *heteropogonoides* from the Philippines, which were previously found to be particularly suited to the dry conditions at Port Moresby.

SEED AND PLANT DISTRIBUTION

The Plant Introduction section also handles distribution of locally grown seed and planting material. Interesting developments in this field included production of seed of *Centrosema pubescens* in the Markham Valley. This species is widely used as a cover crop in coconut and rubber plantations and as a legume component of lowland pastures, but seed has generally been scarce in the Territory, because of failure to set seed under the wet conditions where the plant is mainly grown. Organization of seed collection in the Markham Valley through the Rural Progress Societies gave a response beyond expectations, and several tons of seed was purchased. This source should be able to produce a permanent supply of seed sufficient not only for local demand but also for export.

Another project was the collection of sweet orange seed from the inland Mekeo region (Central District) in response to a request by a commercial importer in New Zealand for citrus seed for the growing of rootstocks by nurserymen. However, cessation of a direct shipping link with New Zealand means that seed would have to be sent by air-freight, and the project would no longer be economic.

Observations have indicated that Avocado (*Persea gratissima*) grows and produces fruit under varying conditions in the Territory, including the highlands. The avocado fruit is highly nutritious, containing considerable quantities of vegetable fat and thus could make a useful contribution to the diet of village people. In order to extend the range of types in the Territory, grafted avocado trees of six varieties were imported from Australia for the establishment of plots at Goroka, Korn Farm (Mt. Hagen) and the Agricultural Training Institute at Popondetta. In addition, arrangements were made for avocado seed from Keravat to be distributed for Extension work at Goroka, Mt. Hagen and Kerema.

Attempts were made to establish cashew nuts in various parts of the Territory and seed was distributed. Interest has not so far been great.

QUARANTINE SERVICES

The plant quarantine service of the Territory is maintained by the Department of Agriculture. The general procedure involves interception of goods by a Plant Quarantine Officer prior to release from Customs bond. A Papuan and a New Guinean have been trained for this work and have been appointed as full-time quarantine officers with full statutory powers, one being located at Port Moresby and the other at Rabaul. All plant material detained for quarantine is grown at Laloki Quarantine Station and inspected regularly by Departmental specialists. The insect-proof quarantine house at Laloki is illustrated in Plates 21 and 22.

Close attention has been given to measures to prevent the introduction of pests or diseases from West New Guinea following the discovery of the coffee berry borer, *Stephanoderes hampei,* at Manokwari, and an unconfirmed report of Panama disease of banana, *Fusarium oxysporum cubense,* near Hollandia (now Kota Baru). This dangerous insect and plant disease could easily be carried across the border in infested unroasted coffee beans or infected banana suckers. In addition, the western half of the island is in close contact with the Indonesian archipelago where there are many plant diseases not recorded in New Guinea. These include coffee rust, *Hemileia vastatrix,* and blister blight of tea, *Exobasidium vexans,* both known to be spread by wind borne spores; downy mildew of rubber, *Oidium heveae;* and rice blast, *Pyricularia oryzae.*

Measures taken to meet the situation have included distribution of information on potentially dangerous pests and diseases to Agricultural and Patrol Officers in border regions so that any introduction might be quickly observed and dealt with. Coffee growing is being discouraged in areas near the border, and special attention is being given to providing alternate agricultural opportunities with lower quarantine risk.

Special attention was also given to quarantine control measures relating to the air service from Manila and Hong Kong to Port Moresby, because of danger from such diseases as cadang-cadang of coconuts and coffee rust present in the Philippines; and to a shipping service and United States Air Force links with Guam, because of danger from infectious yellow mottle disease of coconuts and boil smut of maize. As well as the usual inspection procedures, attention was given to disinsection of aircraft and garbage disposal.

Plate 21. The insect-proof plant quarantine house at Laloki. (*Photo: D.I.E.S.*)

Plate 22. Inspecting introduced plants held for observation in the quarantine house. (*Photo: D.I.E.S.*)

A prohibition of importation of second-hand bags, or materials packed in second-hand bags, had been made in 1960 following discovery of second-hand West African coffee bags in Madang. The prohibition was revised to permit importation of bags from Australia provided they had been steam treated, as complete prohibition had caused hardship to importers of stock-feeds which were normally packed in second-hand bags.

Internal restrictions on plant movement were applied to prevent the spread of *Oryctes rhinoceros, Achatina fulica,* and *Amblypelta cocophaga.*

Action was taken to prevent introduction of weed seeds, notably Noogoora burr (*Xanthium spinosum*) from Australia, when seeds were detected on the coats of imported cattle. The seeds were found to have originated in bedding material used on the ship, and the co-operation of the Departments of Agriculture in N.S.W. and Queensland was secured for inspection of all fodder or bedding exported to Papua and New Guinea.

The water hyacinth *Eichornia crassipes* was discovered in dredge ponds at Bulolo, and measures were taken for its control, including declaration as a notifiable noxious plant. Prickly pear (*Opuntia* spp.) was also declared a notifiable noxious plant, and *Lantana camara* a noxious plant for the whole Territory and *Psidium guayava* a noxious plant in the Wau Sub-District.

PLANT INTRODUCTION AND QUARANTINE STATION, LALOKI

The main function of this station is in the maintenance of quarantine service, and initial planting and multiplication of all introductions. These aspects of the work are covered in the report above.

The station also produces legume seed for distribution, as the dry environment at Laloki is more favourable for this purpose than most other areas of the Territory. *Crotalaria anagyroides, Centrosema pubescens, Pueraria phaseoloides* and *Leucaena glauca* seed were all produced and distributed. A stock of citrus varieties is also maintained, and the station distributes varieties budded on rough lemon, sweet orange and trifoliata rootstocks.

Also under the supervision of this station are experimental plots in the Brown River area and some tobacco experimental plots. The Brown River area comprises about 60,000 acres of alluvial soils lying between the Brown and Vanapa Rivers, about 30 miles from Port Moresby. A soil survey indicated that the land was marginal in many respects for agriculture, and test plots were therefore laid down for observation of crop growth. A first plot was planted in 1955 and 1956, a second in 1957, and a third in 1958 and 1959. In 1962 a clonal cacao garden was planted. Notes on performance of the various crops are as follows:

Coconuts

These made very good growth in the early years, but after about six years the first-planted palms started to show signs of distress, and at about the same age palms in the second plot showed similar symptoms. Those in the third plot, not yet six years old, continue to grow well. At June 1963, the oldest palms looked extremely poor with badly developed crowns and very little fruit. Chemical, pathological and entomological studies have not yet elucidated the cause of the decline, but it is evident that caution would be needed in recommending any crop without prolonged observation.

Cacao

These plants made fairly good growth once established, but there was difficulty in establishment owing to irregular rainfall. Establishment of shade was also slow because of the pronounced dry season. A trial plot was planted in 1962 to test a number of Keravat clones under local conditions. Again there were establishment difficulties, but cuttings which established successfully were growing well.

Coffee

Similar establishment problems were found with coffee as with cacao, but once established, growth was good and production reasonable.

Rubber

This crop grew well once established and at June 1963, continued to look a suitable crop for the area.

Citrus

Trees made fair growth initially, but declined badly after a few years.

Tobacco

Field trials with tobacco were commenced at Laloki and the Brown River area in 1961-62. In the first season, despite difficulties with flooding in the wet season and problems in handling and curing the crop, reasonable results were obtained. However, the leaf was somewhat lacking in the body and weight required by local manufacturers. In the 1962-63 season, growth was generally uneven and quite disappointing, and again the leaf lacked body and weight. Trials will be continued as with greater experience more consistent results may be obtained.

Plate 23. Tobacco curing barns at Laloki: The front barn is for smoke-curing and the rear barn for flue-curing.
(*Photo: D.I.E.S.*)

PLANT PATHOLOGY

The Plant Pathology Section has laboratories at Port Moresby and at Keravat. The Headquarters Laboratory at Port Moresby is engaged primarily on the identification of plant diseases, the central advisory service for all plant diseases for both Papua and New Guinea and the supply of *Rhizobium* inoculum for legumes for cover crops and pastures. In addition to the provision of these services, research work is undertaken in these fields. The second laboratory, at Keravat, is engaged in research on virus diseases and on *Phytophthora* pod rot of cacao.

GENERAL PATHOLOGY

The laboratory at Port Moresby handled 409 accessions in 1961-62 and 346 in 1962-63. These consisted of material submitted by the general public or agricultural officers for identification and advice on control, and material collected in the field during surveys and investigations. The main cultural work carried out was the isolation of organisms from the various accessions for identification and for special studies.

Papers published during the two-year period included the following—

Dorothy E. Shaw:—" Coffee rust risk to Papua and New Guinea " *Highlands Quarterly Bull.* **3**: 9-10, 1962.

This paper reviews the factors probably responsible for the non-occurrence of coffee rust in the Territory to date, such as vigorous quarantine, small catch crop area and distance from inoculum source, and discusses the possible importance of these and other factors in the future.

Dorothy E. Shaw:—" Diseases of Coffee in Papua and New Guinea " *Papua and New Guinea agric. J.* **15**: 1-6, 1962.

The symptoms of, and control measures for, diseases of coffee present in the Territory are discussed in this paper for the planting community.

Dorothy E. Shaw:—" Diseases of cacao in Papua and New Guinea " *Papua and New Guinea agric. J.* **15**: 79-90, 1962-63.

This is a companion to the preceding paper, produced for cacao growers in the Territory.

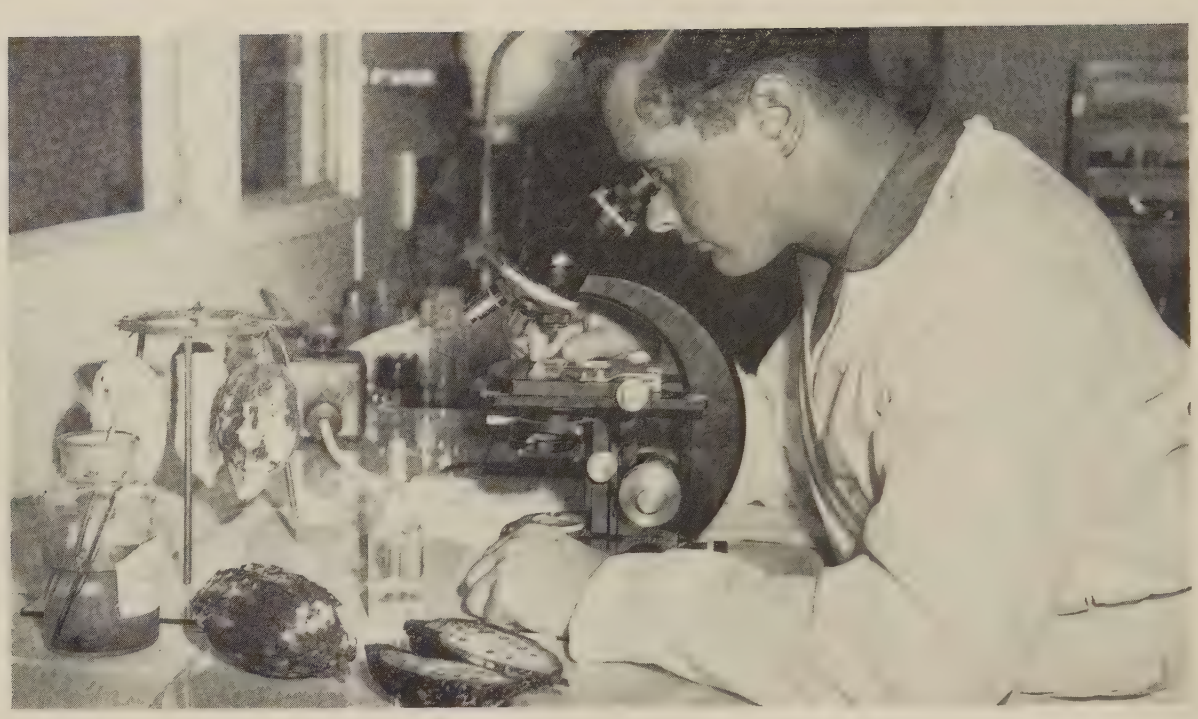

Plate 24. Plant pathologist at Keravat laboratory studying cacao pod rots. *(Photo: D.I.E.S.)*

Dorothy E. Shaw:—" Plant pathogens and other microorganisms in Papua and New Guinea " *Dept. Agriculture, Stock and Fisheries, Res. Bull. No.* 1., pp. 1-78, 1963.

This publication includes all the published records which the author has been able to locate, and those records made by the author from October 1955 up to February 1963. It includes fungal and bacterial pathogens, algae, hyperparasites and parasites of insects closely associated with plants, viruses demonstrated experimentally and virus symptoms, together with the published references to fungi not associated with hosts.

Dorothy E. Shaw:—" Annotated list of references to plant pathogens and miscellaneous fungi in West New Guinea " *Dept. Agriculture, Stock and Fisheries, Res. Bull. No.* 1: 79-81, 1963.

This list, together with the paper immediately above, brings together for the first time all the references the author has been able to locate for the island of New Guinea.

Cacao Die-back: Research work, which has already been under way for several years, continued on this problem. The pathological studies are directed to ascertaining the precise role played by *Botryodiplodia theobromae* in the condition, and include histological studies of infected material, (particularly of young trees with infection but without dead wood), inoculation tests on seedlings and mature trees under various conditions, cultural studies with isolates from infected and dead wood and investigations on spore dispersal. Die-back readings continued to be taken on the trial with seven nutrient treatments, with and without insecticide and with and without fungicide, laid down in the Markham Valley in 1960.

Other research work being carried out by the pathologists at Port Moresby and Keravat includes studies on the fungi causing root rots of cacao and other hosts, the incidence and control of *Phytophthora palmivora* on cacao, particularly on pods, and other aspects of fungal diseases in the Territory.

VIROLOGY

Papers published on the virus investigations included the following—

R. J. van Velsen:—" Cassia mosaic, a plant virus of *Cassia* spp. in New Guinea." *Papua and New Guinea agric. J.* **14**: 124-127, 1961.

This paper presents experimental data on the host range and physical properties of cassia mosaic, a previously undescribed virus disease of *Cassia occidentalis* in New Guinea. The virus is readily transmissible to *Cassia occidentalis, C. tora* and *Crotalaria anagyroides*. The dilution end point lies between 1:1,000 and 1:2,000, thermal inactivation point between 60° and 62° C. for an exposure

of 10 minutes and longevity *in vitro* less than 168 hours. To date no insect vector has been located and the virus is not seed transmitted in *Cassia occidentalis* or *C. tora.*

R. J. van Velsen:—" Little Leaf Virus on *Acalypha wilkesiana. Papua and New Guinea agric. J.* **14**: 128, 1961.

The presence of virus was demonstrated by the appearance of symptoms after grafting affected scions on to disease-free rootstocks. No transmission was achieved using *Bemesia tabaci* or mealy bugs and the virus could not be transmitted by mechanical inoculation.

R. J. van Velsen:—" Cowpea mosaic, a virus disease of *Vigna sinensis* in New Guinea ". *Papua and New Guinea agric. J.* **14**: 153-162, 1962.

This paper records a study of a mosaic virus disease of *Vigna sinensis* in New Britain. Field observations on its occurrence and symptoms are recorded together with experimental data on host range and mechanical, insect, and other modes of transmission. The virus was found naturally in the field on *V. sinensis* and *V. sesquipedalis.* The host range is restricted mainly to the Leguminosae, although *Nicotiana rustica* and *Sesbania speciosa* were artifically infected. The virus is mechanically transmissible, has a thermal inactivation point between 60° and 62° C. for exposure of 10 minutes, a dilution end point of 1:4,000 and a longevity *in vitro* of less than 84 hours. The virus is transmitted by *Aphis gossypii* and *Myzus persicae* in a non-persistent manner but not by *Toxoptera aurantii, Aphis craccivora, Halticus tibialis* or *Planococcus citri.* It is not seed transmitted. Although no serological investigations were carried out, the virus appears to be related to other mosaic viruses of cowpea investigated by McLean (1941), Snyder (1942), and Yu (1946).

Studies were continued on virus conditions of sweet potato, *Hippeastrum*, and " Aibika " (*Hibiscus* sp.) and on a possible virus condition of taro.

LEGUME BACTERIOLOGY

The supply, maintenance and testing for efficiency of rhizobium cultures of 22 species of legumes was carried out at the Port Moresby laboratory. During 1961-62, 2,630 bottles of inoculum were supplied to the general public and to agricultural officers for distribution, and 871 bottles in 1962-63.

Studies on many aspects of the rhizobium work continued and included the following—

(i) isolations of rhizobia from tropical legumes;

(ii) observations on the nodulation in the field of various tropical legumes;

(iii) tests of the effectiveness of rhizobia isolated from *Leucaena leucocephala;*

(iv) study of the effect of storage under oil on these cultures;

(v) study of the inability of the rhizobia from the other hosts tested to date to nodulate *L. leucocephala*;

(vi) investigation of the effect of isolates from *L. leucocephala* on other legumes known to be in the cowpea miscellany;

(vii) study of the presence or absence of the *Leucaena* rhizobium in soils in the Popondetta district.

During these studies various new techniques were developed.

ECONOMIC ENTOMOLOGY

Work continued during the two years on the major projects of control of coconut dynastid beetles and cacao borers, and special attention was given also to control of lepidopterous defoliators of cacao and attempted eradication of the giant termite in Lae. Many other minor projects were also commenced or continued.

Visiting Specialists

Visits from overseas specialists were fewer than in previous years. In most instances, interest was centred on collection of material from limited groups. Visitors included two staff members from Queensland University collecting *Drosophila* spp., and collectors attached to the Bishop Museum, who spent varying periods collecting in a number of areas, apart from the general collecting and ecological work carried out by the staff of the Museum Field Station at Wau. Mr. W. W. Brandt of C.S.I.R.O. spent several months assembling lepidopterous material for the Australian National Insect Collection.

Of agricultural interest were visits from Mr. F. J. Gay in connection with *Mastotermes* at Lae and *Coptotermes* in pine at Bulolo; Mr. K. R. Norris, concerned with screw-worm flies near Port Moresby and in the Markham Valley; and Dr. A. F. Posnette who was interested in cacao insect pests and pollinators. Dr. A. E. Emerson collected termites in the more accessible areas of the mainland of New Guinea, and he estimated that the number of species he found at least doubled the present number recorded for the Territory. Dr. C. P. Hoyt, Technical Officer, Pests and Diseases, of the South Pacific

Commission, spent three and a half months investigating possible natural enemies of dynastids. His principal interest was in the incidence of nematodes in the genitalia of dynastids and *Rhynchophorus*.

Identification by Overseas Specialists

Sixty-six consignments of insects (1,535 mounted insects and 156 vials containing insects and other arthropods preserved in alcohol) were forwarded overseas in 1962-63, though numbers in 1961-62 were much lower. Many specimens are not identified to the species level, indicating the general lack of knowledge of New Guinea insects. Specimens were forwarded to the following persons: Mr. I. F. B. Common (Australia), Mr. C. E. Drake (U.S.A.), Mr. F. J. Gay (Australia), Dr. J. L. Gressitt (U.S.A.), Miss K. Korboot (Australia), Dr. K. V. Krombein (U.S.A.), Dr. C. S. Li (Australia), Dr. M. O. de Lisle (France), Dr. E. N. Marks (Australia), Mr. G. Marsh (U.S.A.), Dr. L. P. Mesnil (Switzerland), Dr. C. D. Michener (U.S.A.), Dr. Nakamura (Japan), Dr. K. R. Norris (Australia), Dr. L. W. Quate (U.S.A.), Dr. F. Salmon (New Zealand), Dr. K. E. Schedl (Austria), Mr. C. N. Smithers (Australia), Dr. E. A. Steinhaus (U.S.A.), Dr. E. L. Todd (U.S.A.), Dr. J. van der Vecht (Netherlands), Dr. A. Wattanapongsiri (U.S.A.), Dr. C. Willemse (Netherlands), Dr. E. O. Wilson (U.S.A.), and several specialists at the Commonwealth Institute of Entomology, and the British Museum, London.

Card Registers of Insects and Collection

Extension of the collection and re-organisation in a more permanent form is well under way and insects are being transferred from storage boxes to metal cabinets. A large drying cabinet has been installed for the quick treatment of fresh specimens and this facilitates the work considerably.

The card register system of insects of economic importance was kept up to date, and a generic register of specimens was completed.

Series of duplicates (including some paratypes) were sent to C.S.I.R.O., Canberra, for incorporation in the National Insect Collection.

Extension

Advisory and identification work by the section continued to increase and included a number of queries on arthropods other than insects. Several visits were received from representatives of insecticide manufacturing firms, resulting partly from the extensive spraying necessitated by the defoliating caterpillars of cacao but also reflecting an increasing interest among the agricultural community as a whole in pest control problems.

Field Trips and Surveys

The caterpillar problem at Popondetta required an entomologist to spend several months there during the two years. Visits were made to Maprik to investigate damage to saksak (sago palm) roofs of village houses caused by the pyralid moth *Herculia nigrivitta*. Lihir Island was visited to investigate a nutfall problem suggested as being caused by *Axiagastus*, and Manus Island was visited to inspect "Sexava" damage. Field surveys were made on Anir Island, Bougainville, and centres in the Eastern Highlands and Central Districts.

COCONUT PESTS

COCONUT DYNASTIDS

There have been no reports of spread of *Oryctes rhinoceros* into new areas. There are, however, reports that the incidence of both it and the indigenous species, *Scapanes grossepunctatus*, is increasing along the east coast of New Ireland, particularly in the younger plantings. There have been several reports of attack by *Scapanes australis* in young coconuts from various parts of Papua.

The general level of incidence of *Oryctes rhinoceros* on the Gazelle Peninsula appears, if anything, to be decreasing.

Biological Control

The Zanzibar scoliid *Scolia ruficornis* is still present in the vicinity of sawmills at Rabaul and Kokopo, and was sighted near a sawmill at Nonga. There is no evidence that it is having any useful effect away from these immediate localities.

The introduced predatory histerid *Pachylister chinensis* was only very occasionally encountered. The Nigerian scaritid *Neochryopus savagei* was not taken in a limited amount of light trapping. The west Indian predators *Leionota* and *Pyrophorus* also appear to have failed to establish themselves. The local predatory dynastid, *Oryctoderus coronatus*, was collected only in small numbers, and, although its

predatory habit was confirmed, the material was not sufficient to make any useful observations on its general habits. Attempts to induce the local scoliid wasp *Triscolia saussurei* to oviposit on *Oryctes* larvae in the insectary failed. No opportunity occurred for further investigation of the local predatory histerid *Plaesius ellipticus*.

The main work done during the period was with the Zanzibar reduviid *Platymerus rhadamanthus*. The normal habitat of this species is the crowns of coconut palms where it is known to prey on adult rhinoceros beetles. A small shipment of eggs and adults was received in 1961-1962, but all adults died in transit. They had laid some eggs (about 200) and these were liberated in batches of 5 eggs per palm at a site on the foreshores of Rabaul harbour. No evidence was found that the insect was established. A further batch of 375 eggs was obtained in December 1962, and it was decided to breed the insects in the insectary so as to be able to make individual releases of the order of 2,000 or more eggs at a time. To realise this, it is estimated that two generations will have to be reared in the insectary and the project will take between eighteen months and two years.

The eggs were held in the laboratory in petrie dishes until the first emergences were noted. These took place about three weeks after the receipt of the eggs and were completed within three days. Fertility of the eggs was high, but a good deal of mortality occurred during the immediate post-emergence period before the nymphs were transferred to larger permanent cages. Subsequent mortality was negligible after the first instar and losses were principally due to escapes.

It had originally been intended to rear the *Platymerus* on cockroaches, but the rearing of the latter was considerably more difficult than raising the predator. In the end an alternative was found, the first two instars being reared on a small termite (*Microcerotermes biroi*) and subsequent instars and adults on the large cacao termite (*Neotermes* sp.).

The first adults emerged 16 weeks after hatching and the remainder over the following four weeks. In all, 66 adults were reared. Oviposition commenced 4 weeks later and by the end of June 1,200 eggs had been laid. With some change in the handling of the emerging nymphs, mortality in the first instar became a negligible factor. The accumulation of eggs for rearing the next generation will stop at 2,000, and subsequent depositions will be accumulated for field release at a number of suitable points in the Territory.

As yet, only limited observations have been made on the predatory habits of *Platymerus*. No evidence of cannibalism has been observed, although they have been noted feeding on an occasional moribund or dead individual. Families on which fifth instar nymphs and adults have fed readily include Dynastidae (*Oryctes* and *Scapanes* adults—the latter less readily than the former, presumably on account of their size), Pentatomidae, Coreidae, Capsidae, Noctuidae (*Achaea* larvae) and Chrysomelidae. Reactions to Acridiidae and Tettigoniidae were largely negative once they were more than half grown. It is likely that the strong hind femur and sudden movements of the larger 'Sexava' and short-horned grasshoppers is sufficient to intimidate the *Platymerus*, which is very timid by nature. However, 'Sexava' up to the third instar were quite acceptable. On this preliminary basis, establishment of *Platymerus* could be an effective weapon against Territory pests which tend to be severe in effect but are usually of limited, localised importance. Included among these would be *Promecotheca, Axiagastus, Amblypelta* and, to a lesser extent, 'Sexava'; and also of course, *Oryctes* and *Scapanes*.

Chemical Control

Laboratory tests confirmed the effectiveness of a sawdust/diazinon mixture against *Oryctes* and *Rhynchophorus* for up to eight weeks. The cheaper sawdust BHC mixture was in use on a number of plantations for treating frond axils of young palms to kill entering adult dynastid beetles.

Extensive damage was caused on the coconut trial (TCN1) on the Vunapau road, Keravat. Only *Scapanes* and *Rhynchophorus* were recovered from the block, indicating that it was far enough from the main Station to avoid damage by *Oryctes*. The principle indigenous host of *Scapanes* in this instance appeared to be *Calamus* sp.

Treatment of palms at Bubia, using gammexane dust, appeared to be effective against *Scapanes*.

Mechanical Control

A commencement with thinning the overcrowded Native coconut plantings on the Gazelle Peninsula has been made by officers of the Extension Division. The disposal of the felled palms posed a formidable problem and several methods were tried to see which would provide the minimum scope for breeding for *Oryctes* and *Rhynchophorus*. In many inspections within a few months of felling, the latter beetle was invariably found to occur most commonly. Populations of both beetles and larvae varied for no apparent reasons from one treatment to another and within any given treatment. It was apparent that cutting

into short lengths, splitting and stacking kept the breeding at a uniformly low level but this method would be extremely laborious, even if its practice could be enforced. Perhaps the most appropriate method under the circumstances would be to cut the trunks into 4-6ft. lengths and treat the ends with a Dieldrin wash.

PALM WEEVIL

Rhynchophorus spp. continued to be the most consistent and insidious cause of death of palms, particularly young ones. No further trials on chemical control were undertaken, as it is considered that the individual palm inspection and treatment of affected palms with a Dieldrin drench is all that can be recommended.

A further search was made at Anir Island for the predatory histerid *Pachylister javanus*, and the predatory carabid *Pseudozaena opaca,* but results were disappointing. Only three dozen adults were collected, and these were liberated in block 402 at Keravat.

"SEXAVA"

Several species of tettigoniids caused damage, of varied extent, in the Admiralty, Hermit and Western Islands groups. It was reported from the Western Islands that damage was noticeably reduced some six months after an active colony of *Leefmansia* from Keravat was released. There were also reports of damage from New Hanover and northern New Ireland. Several shipments of *Leefmansia*, usually in batches of about 2,000 Sexava eggs with a parasitism rate of the order of 80 per cent., were forwarded from Keravat to the Hermits, Manus and New Ireland, and a shipment of 5,000 eggs was sent to Papua.

The main source of parasitized eggs was the oil palm block at Keravat, but as this block has now been largely removed as an *Oryctes* control measure, this source of supply is no longer available. Following a request for parasites for Pak Island, eggs were collected from New Hanover. New Hanover periodically suffers from damage by *Segistidea* to varying degrees but the parasite *Leefmansia* seems, under local conditions, capable of regaining control of the situation without an unduly long time-lag. An increase in the numbers of 'kurukum' ants *Oecophylla smaragdina* at Pak Island was noted. These ants were introduced in 1959, and have made some contribution towards reducing the Sexava population.

Small consignments of Sexava eggs were received at Keravat from both Pak and Wuvulu Islands. Some parasitism was noted in the form of obviously parasitised old eggs, but it is doubtful whether *Leefmansia* was responsible. Sterility in the samples from both sources was particularly high due, no doubt, to desiccation.

While Sexava appears to be present throughout New Britain, it seems to be kept under effective control and no reports of outbreaks have been received for some time.

No progress was made at Bubia in the work on the strepsipteron parasite of tettigoniids. Repeated attempts to locate the male insect have been unsuccessful.

COCONUT LEAFMINER

Moderate populations of the Leafminer *Promecotheca papuana* were noted at several points on the Gazelle Peninsula. However, parasitism was uniformly high and it is not anticipated that any damage will develop.

Both Linga Linga and Lindenhafen Plantations on the north and south coast of New Britain are enjoying a period of relatively high production indicating at least a temporary recovery from previous attacks. It is reported that some village plantings on the north coast not far from Linga Linga Plantation are carrying quite large populations.

In the vicinity of Keravat Station, egg, rather than larval or pupal, parasites appear to be the principal controlling factor.

BRONTISPA

The status of the coconut hispid *Brontispa longissima* remained static during the year; it is everywhere in moderate numbers in young palms where it is capable of causing an appreciable set-back to growth. It is probably most plentiful along the East Coast of New Ireland. It is, however, a simple matter to control it by spraying.

Attempts to rear parasites from this insect continued to be unsuccessful.

AMBLYPELTA

There is some indication that distribution of the coconut nutfall bug *Amblypelta cocophaga cocophaga* is becoming more widespread. It has now been recorded at several localities between the Agricultural Station, Sohano, and Numa Numa on

the east coast of Bougainville. It was present in sufficient numbers on the Agricultural Station, Sohano, to necessitate control measures. It appears that the possibility of cacao serving as a catch crop for *Amblypelta* control will not materialise. Even though the insect was more accessible to control measures when it moved onto the cacao, the population build up was sufficient for the coconut nutfall area to be extended considerably.

AXIAGASTUS

Reports are often received of very high populations of *Axiagastus cambelli* occurring on Bougainville, New Ireland and islands off the east coast of the latter. Together with *Amblypelta* and *Promecotheca,* this species offers a good potential food supply for *Platymerus* if the latter can be established, partly for its localised value and partly to tide the reduviid over its younger stages until it is able to attack the dynastids.

Some trials were carried out at Keravat to gain general information on whether *Axiagastus* was a primary cause of nutfall. A number of spathes were enclosed in cages of fine gauze netting, including spathes which had opened within the previous week, and spathes just due to open. The latter showed evidence of *Tirathaba* attack. Large numbers of *Axiagastus* nymphs and adults were placed in the cages containing unopened spathes. Counts of nuts holding indicated that the spathes caged with *Axiagastus* carried as many as the spathes caged without the bugs. A complete fall of nuts occurred in spathes which were caged, unopened, without introducing *Axiagastus.* In all cases, considerable fall of male flowers occurred due to *Batrachedra,* and of female flowers due to *Tirathaba.* It was evident that this was largely a result of the exclusion of predators. Both spathe moths are capable of laying their eggs on the unopened spathe and their larvae are thus free from attack until the spathe opens. The most frequent predators noted were *Oecophylla,* and various mantids, vespids and eumenids. While the tests were far from conclusive, they indicated that a reasonable number of nuts can be maintained in the presence of a large population of *Axiagastus.* They also threw an interesting light on the effectiveness of predator activity in palm crowns.

An investigation was made of a report of severe losses due to nutfall on Lihir Island, off the east coast of New Ireland. Despite very large *Axiagastus* populations, the primary cause of the drop in production appeared to be the spathe moth, *Tirathaba,* with also considerable fall of male flowers due to *Batrachedra.*

Observations pointed to the scarcity of *Axiagastus* in New Britain being due to a scelionid egg parasite belonging to the genus *Telenomus.* This wasp, said to be a new species, was reared from quite a few species of local pentatomids and coreids, and it is proposed to investigate it further.

COCONUT LIMACODID

Considerable damage by the limacodid *Thosea sinensis* occurred in the Hula area of Papua. Damage had been observed over several years, but it appeared to have spread. A tachinid parasite, *Spogossia grandis,* was reared from the pupae, but only in moderate numbers.

COCONUT SKIPPER

Incidence of this species (*Cephenes moseleyi* Butl.) has become more generally noticeable over the past few years but it is doubtful whether it has yet reached the status of being more than an incidental pest of coconuts.

CACAO PESTS

DEFOLIATING CATERPILLARS

The various species of these caterpillars were the major pest problem in cacao during the two years, particularly in the Northern District of Papua and on the Gazelle Peninsula of New Britain. The amount of damage caused in the Morobe District was of a sporadic nature, while in Bougainville and New Ireland damage was negligible, although an isolated outbreak of the limacodid *Scopelodes* sp. did occur near Soraken Plantation in Bougainville.

The enormous build up of these pests was greatly assisted by the large areas recently cleared and planted to *Leucaena* and cacao. Another factor in the increase was the catholic nature of the food habits of the two most voracious species, *Tiracola plagiata* and *Achaea janata.* There appeared to be during this period greatly stimulated activity on the part of many species of caterpillars in various parts of the tropics, including case moths and noctuids on poinciana (*Delonix regia*) and *Peltophorum* throughout the Territory, *Heliothis* on tobacco and *Achaea* on castor bean at Epo, *Prodenia litura* on vegetables at Wau, and many others. However, by 1963, there was some indication of an improvement in the situation in New Britain at least.

Plate 25. Growing-tip of a 12-month old cacao plant showing the effects of continued defoliation by caterpillars. (*Photo: A. E. Charles*)

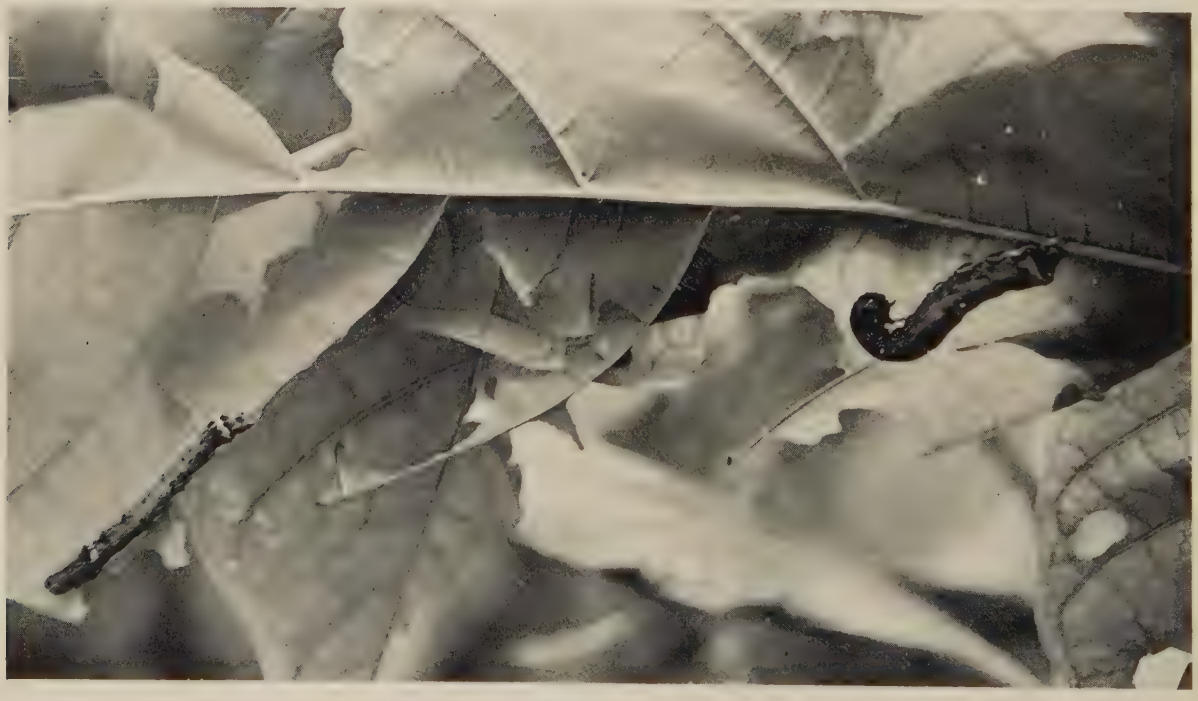

Plate 26. *Tiracola plagiata* **larvae feeding on a young cacao leaf.** (*Photo: A. E. Charles*)

The main species involved at Popondetta in the Northern District have been *Tiracola plagiata* and *Achaea janata*, with occasional slight damage by psychids and lymantriids. In the Morobe District, in addition to the above species, the lycaenid *Iamides celeno* was of localised importance. In New Britain, *Tiracola* was replaced by the geometrids *Ectropis sabulosa* and *Hyposidra talaca*, the former being far more important both in numbers and in its ability to feed on *Leucaena*. Both geometrids occurred in the Markham Valley, but only an occasional specimen of *Hyposidra* was observed at Popondetta.

Laboratory and Field Studies

Life history studies were made of *Tiracola* at Popondetta and of *Achaea* at Keravat. Attempts to investigate the looper *Ectropis sabulosa* at Keravat were largely unsuccessful because of difficulty of handling the younger larvae in the insectary.

Extensive spraying and misting trials were carried out at both centres against the three principal species of caterpillars, and DDT was demonstrated to be the most generally acceptable and effective of the range of materials tried. At Keravat, Sevin was shown to have a somewhat longer residual effect, and certainly a more immediate one, when applied as a spot spray to the flush of young trees with a hand operated or pressurised knapsack sprayer.

Although predation was observed to occur quite commonly, in the face of such large populations of caterpillars it was of little value. The principal insect predators noted were reduviids, pentatomids, asilids and various hymenopterons. Probably the most effective single agent in control was the giant toad which devoured large numbers of *Ectropis* larvae as they descended to the ground on threads to pupate.

Throughout 1961 and most of 1962 parasitism also was slight, and the only control measures that could be recommended were the adoption of an insecticide spray programme timed to coincide with the development of each new cacao flush and each new deposition of caterpillar eggs. This should be relatively simple with *Tiracola* where oviposition, although on a massive scale, takes place at more or less regular intervals and occurs over quite a short period of time. It is more difficult with *Achaea* since the life-cycle is not so rigid and the eggs are laid in smaller numbers over a longer period. It is more difficult again with *Ectropis* whose eggs are laid in large numbers and appear to be mostly secreted in crevices in the trunks of cacao and *Leucaena*, so that by the time young caterpillars are observed to be feeding in the cacao they are already established in the *Leucaena*. However, it was apparent that many instances of severe damage were the result of poor application of spray material and poor timing of the spraying routine.

Late in 1962 and in 1963 there appeared to be in New Britain a trend towards a return to the natural biological balance between caterpillars and their parasite-predator complex. This improvement was most pronounced on the western half of the Gazelle Peninsula and especially in the vicinity of the Agricultural Station. In the eastern half of the peninsula, reports indicated that damage by both *Achaea* and *Ectropis* was severe in some places at some times, moderate in others and slight in others. While some plantation owners were obliged to spray all the year, others experienced gaps of several generations of low density of caterpillars which made spraying only an intermittent necessity.

At Keravat, what appears to be a permanent restoration (at least for an unpredictable cycle) of the caterpillar parasite balance was observed in a fairly clear-cut manner. It was necessary to carry out a regular spraying schedule on most of the younger cacao blocks on the Station for the first six months of 1962. However, concurrently with a gradual, but appreciable, falling off in the level of caterpillar population, a contraction of the area requiring spraying was evident, until, by mid-October 1962, the Clone-Testing Block was the only one requiring any attention. In the three succeeding generations of both *Achaea* and *Ectropis*, the numbers of the caterpillars and the proportion of the block affected declined until, by the end of December, parasitism was almost completely effective.

Progressive checks of parasitism with each generation showed that figures for both species ranged from 2.5 to 5.0 per cent. in each generation until the rate started to rise in October 1962. The larval parasites comprised an undetermined species of braconid (which subsequently disappeared altogether) and tachinids. There are probably three species of the latter involved, but efforts to have them determined specifically have been unsuccessful. It is apparent, however, that the commonest Papuan species, *Exorista fallax*, is not represented in New Britain, nor do the local species appear to be present in Papua.

The October generation of *Ectropis* at Keravat gave a parasitism rate of 18 per cent. which rose to

22.5 per cent. in the following generation. Numerous samples from the January generation gave rates ranging from 35 to 70 per cent. and by this time the tachinids were very commonly seen on the wing. Spraying was discontinued prior to this generation and has not since been necessary. The tachinids did not attack *Achaea* as readily as *Ectropis* but the former lagged only one generation behind the latter species before it also virtually disappeared. What was considered to be an appreciable factor in the ultimate decline of both species was the amount of feeding by the Giant Toad (*Bufo marinus*) while the caterpillars were preparing to pupate. It is of interest that almost 20 per cent. of the penultimate generation of *Achaea* larvae were parasitised by an undertermined gordian worm, some specimens of which were almost 2 feet long.

On further investigation of the reasons for the decline in *Achaea* numbers, it was apparent that egg parasites were largely responsible. There are two of these, a scelionid (*Telenomus* sp.) and a trichogrammatid (*Trichogramma* sp.—noticed first shortly after the release of the imported *Trichogramma* mentioned below). Although no regular rearings of eggs for parasites had been made for some time, no trichogrammatids had previously been bred out and it is thought that, as with the tachinids, they also had only just commenced to build up in numbers. These egg parasites also were responsible for the virtual disappearance of a newly-recorded leafroller of cacao, *Striglina rufofasciata,* Fam. Thrydidae.

Elsewhere on the Gazelle Peninsula, the decline of the caterpillar population was not nearly so pronounced as it was at Keravat, although both tachinids and egg parasites were observed in some localities in numbers that would have appeared to warrant a more discreet use of insecticides.

The caterpillar position at Popondetta was lagging considerably behind that on the Gazelle Peninsula in respect of parasitism. In all probability this was due to a combination of factors such as the considerably greater extent of the continuous planting of cacao and *Leucaena,* the biological characteristics of *Tiracola,* particularly those tending to make it an awkward host for parasites, and adverse weather conditions.

It is not possible to say when some restoration of the *Tiracola* balance can be expected. However, it does appear that the various parasites will not be able to exert any useful influence until such time as the present 'one stage' condition of the pest species breaks down, that is, until all stages are present at the same time, thereby permitting a continuous build-up of the parasites. Under the conditions obtaining at present, although parasites may be numerous at the end of one generation, the majority will continue to die out before the next suitable stage of the host is present in worthwhile numbers.

Biological Control

In an effort to assist in restoring the natural biological balance between the pest and its environment, steps were taken to introduce parasites from overseas. Bulk liberation was considered desirable and it was decided that a species of *Trichogramma,* which could be purchased in quantity from a commercial insectary, offered the best quick-term prospects of useful results. After other sources had been tried unsuccessfully, Rincon Insectaries, California, agreed to supply in bulk a mixed culture of *T. minutum* and *T. semifumatum* in eggs of the Grain Moth *Sitatroga cerealella.* A trial shipment in December 1962, indicated that the wasps would survive the trip readily. Accordingly, two shipments, each of five million parasitised eggs, were ordered and duly received in January and February 1963. The bulk of these two shipments were released at Popondetta, but small batches were sent on to Keravat for local release and to Gobari Plantation, Lae, while small releases were also made at various points in Port Moresby. In May 1963, a further shipment of 2½ million was received at Keravat for release on the Gazelle Peninsula. For some reason, emergence from this shipment was very poor, only about 5 per cent. of the parasites emerging successfully. A replacement shipment was supplied in June and its emergence was very high (upwards of 90 per cent.). In this case, only 1 million eggs was ordered as it had been amply demonstrated in the interim that a local species of *Trichogramma* was beginning to take an active part in controlling the caterpillars.

Liberations on the Gazelle Peninsula were made at various points between the eastern coast of the peninsula and Asalingi Plantation in the Bainings. Liberations at Kulon Plantation and in the Bainings were made primarily against the cacao bark moth, *Pansepta,* which was particularly severe in those two areas. The eggs of this moth are laid singly on the bark of youngish cacao branches and would be readily accessible to the *Trichogramma* if it will work in such an environment, as it has been shown to be capable of doing in quite dense cacao at Keravat.

Recoveries of *Trichogramma* were made at Keravat immediately following the emergence of

introduced individuals. However, the extent of the area over which *Trichogramma* was recovered showed that, even if the introduced parasite was established, an indigenous species was also present. Considerable difficulty has been experienced in having the parasites fully determined, but it seems certain that all the rearings, from Keravat at least, have belonged to the *T. japonicum* complex. This species, or complex of species, has a distribution ranging from Japan to Indonesia, so although it has not previously been recorded from New Guinea its presence in the Territory is not unexpected. No definite recoveries of *T. minutum* have been made in New Britain. *Trichogramma* has so far been reared from six species of Lepidoptera at Keravat, in fact from all species whose eggs have been examined. It has not been reared from eggs of *Ectropis* as none of these have been located since observations were commenced on the egg parasites. From the same range of species, a scelionid, variously determined as *Telenomus nawai, T. remus* or *Telenomus* sp. has been continually reared. It is quite possible that a complex of species is involved both in the islands and on the mainland. However, again it has not proved possible to get precise specific determinations in this group. In most rearings, *Telenomus* (at Keravat) has been the dominant egg parasite and it is thought that it, rather than the tachinids, are the principal cause of the marked decline in the *Achaea* population locally, while it was the tachinids that were responsible for the decline of *Ectropis*.

At Popondetta, in Papua, the position was different. After the bulk introductions of *Trichogramma* to the district early in 1963, no egg parasites were reared from either *Achaea* or *Tiracola* up to mid-April, 1963. However, an examination in June 1963, showed that, despite a prolonged spell of dry weather, parasitism of *Achaea* by a *Trichogramma* was occurring throughout the district. The rate of parasitism of various samples varied from a trace to as high as 91 per cent. in a total of 2,000 eggs examined. The rising percentage appeared to be correlated with rainfall to some extent, increasing perceptibly from east to west across the district. In most cases, *Trichogramma* was the principal egg parasite reared from *Achaea* although a *Telenomus* was also present, the ratio of the two being almost the reverse of that observed at Keravat. The *Trichogramma* was also reared from eggs of *Pericyma cruegeri, Catopsilia pomona* and several other undetermined caterpillars.

A subsequent survey at Popondetta during a period of egg-laying by *Tiracola* showed that adults of what was presumably the same species of *Trichogramma* were seen walking over the egg batches and ovipositing. In one instance, a dozen adults were seen on one batch, though there were usually only three or less. *Trichogramma* was observed on a reasonable proportion of the egg batches examined.

From general observations, and allowing for the general voracious habits of the *Tiracola* larvae on emergence, it appears likely that unless a high proportion of the eggs have been parasitised, the parasites will be killed *in situ* by being chewed by the emerging caterpillars. For this reason, while *Achaea* can reasonably be expected to decline in numbers at Popondetta in the not too distant future, a contribution to the control of *Tiracola* by *Trichogramma* will be a much more protracted process, again being dependent on the breaking of the 'one-stage' condition of the host as well as the necessity to build up to a very high population level before it can hope to be effective.

It is evident that much more detailed work on the parasite complex of the defoliating caterpillars is necessary but much of this is dependent on a precise determination of the species involved in different parts of the Territory. The scope for introduction of additional species of parasites from overseas is also considerable.

Results of the releases of *Trichogramma* at Lae and Port Moresby have been invariably negative, and rearings have been devoid of any trace of *Trichogramma* or, indeed, of *Telenomus*. As regards the scelionid egg parasite, only a bare trace of it was found in eggs of an undetermined noctuid at Bubia, near Lae.

Several small shipments of an unspecified tachinid parasite on *Spodoptera* were introduced to Keravat from Hawaii. These parasites travelled well and emerged successfully. The parasite was observed several generations later in the field, but it is most unlikely that it will become permanently established as the decline in the host population at the time of its introduction was very rapid.

A shipment of the Mainland tachinid, *Exorista fallax*, was made from Port Moresby to New Britain but the emergence was poor and only 24 specimens were eventually released. Several shipments of the tachinid parasite of *Ectropis* from material collected at Keravat were made to Popondetta and to Honolulu, but these introductions must be considered as haphazard as the identity of the species and its host preferences (apart from *Ectropis*) are not known.

CACAO WEEVIL BORERS

Weevil borers of the genus *Pantorhytes* are becoming more evident in the Territory as larger areas of cacao approach maturity. An illustration of the wide distribution of the genus was seen in the presence of large numbers of a probably new species on the native host tree, *Pipturus,* on Anir Island. Bougainville and New Ireland are still relatively free from weevil damage on cacao, although a new species was taken on cacao near Kieta, Bougainville, in 1963. Most of the plantings in these two areas are still relatively young, and being mainly on a large scale, the danger of infestation from secondary bush is reduced. Increasing damage was evident in the Gazelle Peninsula (*P. plutus*), at Popondetta (*P. szentivanyi*) and in the Morobe District (*P. proximus*), and several new species were recorded for the Territory. Spraying experiments on the control of the adult weevil (*P. plutus*) on a plantation adjacent to Keravat were reconstituted in 1961 by shortening the intervals between sprayings, and using DDT in different forms and with several different carriers. This schedule was continued for just over a year, but analysis showed that although appreciable declines in weevil population followed each spraying, the overall reduction at the end of the trial was not significant. The extent to which this was due to a large larval reservoir and the ingress from nearby native hosts is not known, and spraying of this plantation had been difficult because of rough terrain and mixed age of the trees. However, the results confirmed the view that attempts to kill the adult weevils by spraying would not be economic, and it was decided that further work would be concentrated on *in situ* treatment of the larval stage. Trials were commenced involving both surface treatment of the borer channels and injection of insecticide into the channels. The limited numbers of borer infested trees at Keravat restricted the studies. There were indications that such insecticides as Diazinon and Lebaycid may form the basis for an economical method of control.

CACAO LONGICORN BORERS

At Popondetta and Talasea, the longicorn borer *Tmesisternus* sp. appeared to be increasing. However, New Britain and Madang Districts were the main areas of longicorn damage and *Glenea* and *Monohammus* species were most important. Damage was usually confined to a small group of trees on a plantation, but was often severe on these. This indicates a low level of adult population with a highly successful oviposition, unlike the weevil borers.

Cacao on Bougainville and New Ireland continued to be virtually free from longicorn damage.

CACAO CAPSIDS

The position with respect to cacao capsids appears to be fairly static. Periodically sizeable pod losses occur but, in general, control of the pest whenever it appears has been incorporated into normal plantation routine, as it is appreciated how heavy the losses can be and how simply they may be avoided.

Both *Helopeltis* and *Pseudodoniella* showed some decline in the Popondetta area. There was little damage reported from the Markham Valley, and in the Madang District *P. laensis* was reported from only one plantation. *P. typica* sometimes caused persistent damage in the Gazelle Peninsula, but this was probably a result of faulty spraying or dusting techniques.

Trials comparing insecticidal spraying against dusting showed Endrin to be more effective than Telodrin or Malathion. Endrin gave good control as a mist at 0.025 per cent. in water. For moderate infestation, cost of materials would be about one shilling per acre. The treatment appeared to have some ovicidal action, as a second misting was often unnecessary.

AMBLYPELTA SPECIES

Incidence of *Amblypelta costalis szentivanyi* was very light in the Gazelle Peninsula, but *A. cocophaga cocophaga* is continuing to spread on Bougainville, and in the Northern District *A. theobromae* is probably responsible for the loss or distortion of more pods than all the other pod-infesting insects combined.

The scarcity of *A. costalis szentivanyi* in the Gazelle Peninsula could possibly be due to the activity of a scelionid egg parasite which has been bred from the eggs of a very closely related genus, *Dasynus*.

COFFEE BORER

The cossid borer *Zeuzera coffeae* has increased in severity in New Britain, but there are no reports to indicate that it causes appreciable losses elsewhere in the Territory. The scattered nature of its attack precludes the adoption of any method of control other than removal of affected branches and subsequent destruction of the larvae.

BARK CHEWING INSECTS

The xyloryctid moth *Pansepta teleturga* extended its activity on the Gazelle Peninsula and is becoming a pest of considerable significance, particularly on

plantations where cacao is grown under coconuts. In sole-planted cacao the insect is much more sporadic in its attack.

No progress has been made with the bionomics of *Pansepta* owing to its continued failure to appear at Keravat. Several plantations have carried out spraying trials combined with pruning procedures but no conclusive results have been derived from them. In general, reasonable control can be maintained if pruning of affected branches is started as soon as signs of damage are observed.

The two Bark Moths, *Conopia* spp., are still of little significance and their appearance is usually associated with older and unthrifty trees.

MEALYBUGS, SCALE INSECTS AND APHIDS

Incidence of mealybugs and aphids was quite high generally in most parts of the Territory, and the population appeared to be most obvious where continued DDT spraying had been carried out for control of caterpillars. Mealybugs can cause tip-distortion and some dieback when their attack is heavy, and have been suggested as possibly predisposing to infection by *Botryodiplodia*. Satisfactory control can be obtained with a white oil-Malathion spray, although when the attendant fire ant (*Solenopsis* sp.) is abundant it is necessary to control these before obtaining good mealy bug control. The citrus aphid, *Toxoptera aurantii*, was frequently noted in large numbers on young flush leaves, but caused no apparent damage.

POD BORING INSECTS

The pod-boring moth *Olethreutes* sp. was noticed causing some damage on several northern Bougainville plantations and consistently caused moderate pod losses on many plantations in the Gazelle Peninsula. Further life history observations were made. Although the insect is often associated with capsids, it does not need the lesions made by capsids to effect entry into the pod.

On one plantation in Bougainville, pod rot was observed caused by a tipulid, *Limonia* sp. Although the species is perhaps dependant on lesions caused by *Amblypelta* for its initial entry into the pod, once the maggot has gained entrance it is capable of acting as a primary pest. Breakdown of the pod by secondary fungi is rapid since, unlike *Olethreutes*, *Limonia* is capable of penetrating the hard inner shell of the pod, and most of its feeding is actually done on the beans.

CACAO TERMITES

Activity of the two *Neotermes* species in New Britain and New Ireland increased considerably. The New Ireland species, *N. schmidti*, was found in abundance on Anir Island, attacking young cacao. In the Gazelle Pennisula, attack on *Leucaena* was severe, and is increasing with extensive shade thinning being carried out. There is also evidence that the species is developing the capacity to enter the cacao tree via the living root in the manner of the New Ireland species. Control requires regular inspection of the cacao with careful attention to pruning methods.

MISCELLANEOUS INSECTS

Observations were made on a widespread small gracilariid moth, *Acrocercops* sp. The larvae mine below the epidermis of young shoots and leaf petioles, often causing it to peel off in large quantities. The effect appears to be of no economic importance, but the possibility was considered that the unprotected tissue might serve as an entry point for fungi. No indications were observed of this happening.

A number of instances of quite severe leaf damage by eumolpids (*Rhyparida* spp.) were reported from various parts of the Territory.

Some incidental observations were made on the presumed principal cacao pollinating insect, *Forcipomyia* sp. Its larvae are present throughout the year and may be readily found on the under surface of apparently any tree or shrub. Preferred leaves are old, lichen covered, soiled with cast skins of springtails, old scale insects, and suchlike detritus. It is presumed that they feed on this rubbish. Pupation occurs on the feeding site. Although present all year round, there are periods when the insect is especially abundant. Despite the fact that the adults did not appear to move over any great distance, there was no sign of even repeated sprayings having any effect on their numbers.

OTHER PESTS OF ECONOMIC PLANTS

COFFEE

The general incidence of coffee pests continued to be low, particularly in the Highlands areas. The shothole borer *Oribius*, though present in small numbers in a number of localities, appeared generally to be declining. The ring borer (*Meroleptus cinctor*) was also present only at a low level, but large areas of

Native coffee were treated as a precaution against it. This insect (illustrated in plates 27 and 28) is primarily a pest of young coffee, when the larvae girdle young stems. Though seldom causing death, they do cause loss of a year's production from affected stems. The leafhopper *Batrachomorphus* sp. was mainly confined to the Kainantu area and its numbers fluctuated widely, owing partly to a wasp parasite and partly to fungal attack. Studies on the bionomics of this insect were continued at Aiyura.

Green scale and mealybug occurred on *C. canephora* at Keravat in quite considerable numbers, and spraying with white oil-malathion mixture was necessary. Undoubtedly the fire ant, *Solenopsis* sp., was the principal factor in their continued recurrence since predatory coccinelids are usually capable of keeping the insect within reasonable limits.

The coffee borer *Zeuzera coffeae* was recorded from a number of localities on the mainland, and in the Central District severe shot-hole damage was caused by *Idiopsis* spp. weevils in one area. The root mealybug *Paraputo leveri* was recorded as causing severe damage near Mumeng.

RUBBER

In general, insect pests of rubber were of only minor and localised importance, mostly confined to young plants or seedlings in nurseries.

There was a quite serious attack by *Tiracola* on rubber seedlings at Kokoda, but the caterpillars were controlled by a single D.D.T. treatment. Two celeuthetine weevils (*Idiopsis* spp.) caused continuous minor damage to rubber seedlings and recently-budded material, and repeated sprayings were often required to keep the numbers down. The *Araucaria* Termite *Coptotermes elisae* caused serious damage to seedlings at Bisianumu.

GIANT AFRICAN SNAIL

The snail continued to spread down the East Coast of New Ireland, but progress down the West Coast appeared to be slight. In New Britain spread continued only slowly, and isolated foci in the Bainings area have not joined up.

The predatory snail *Euglandina rosea* was not recovered from any of the sites where it had been liberated several years ago, and it appears that it was not successfully established. The other predatory snail introduced, *Gonaxis kibweziensis*, maintained itself but did not show promise of achieving the success reported from parts of Hawaii. Two small lots were collected at Keravat during 1961-62 and were distributed, but collecting was discontinued for fear of destroying it. There appeared to be some increase in numbers by 1963.

A further small shipment of the drilid *Selasius* sp. was received from Nigeria, but only a dozen females survived, so nothing could be done with them.

TIMBER PESTS

Giant Termite

The giant termite, *Mastotermes darwiniensis*, was first detected in the Lae township in 1961, but it appears that it actually entered the Territory in hardwood logs imported by the Army during the 1939-45 war. Although the fact that in eighteen years the insect had spread over an area of only 44 acres may indicate that the environment of Lae is not entirely sutiable for the species, it could prove much more serious in drier areas such as the mid-Markham Valley. The insect was therefore gazetted a 'notifiable pest' under the Plant Disease and Control Ordinance of 1953, and a concerted effort was made to map the infested area so that the colonies could be isolated and treated with a view to ultimate eradication. Considerable work was involved in the project, which was greatly facilitated by the co-operation of various Administration Departments and the occupants of the infested properties.

Initially, the infested area was examined by Mr. F. J. Gay of C.S.I.R.O., who visited the Territory specifically for this purpose. He agreed that eradication was a reasonable aim, and also that the eradication measures that had been drawn up were adequate for the purpose. The first step was locating and assessing the extent of all the colonies. As about two thirds of the area infested was waste or unoccupied land, it was cleared to ground level and all rubbish was stacked and burned. Infestation of living material was quite extensive and included such species as rain trees, rambutans, kapok, citrus, tapioca and many species of secondary bush trees and shrubs. In all, an area of 28½ acres was eventually ploughed and treated with 2½ per cent. Aldrin dust at the rate of 50 lb. per acre. This was then cross-ploughed to get the insecticide well mixed with the soil. Debris from the second ploughing was again collected, stacked and burned and the many small colonies thus revealed were treated with a 0.5 per cent Dieldrin drench. All active colonies located in buildings were treated with an arsenical dust or watered with a Dieldrin solution. The main colony centres were gradually located and these were surrounded by a 12 in. trench which was watered with a 0 5 per cent. Dieldrin solution at the rate of 1 gallon per ten feet of trench. In the case of very large and active colonies this trenching involved areas several acres in extent. In any case, the area enclosed by the trench was designed as far as possible to include all the runways of the colonies located.

Plate 27. Adult coffee ring borer, *Meroleptus cinctor*, on a stem of sweet potato, its alternate host plant. (*Photo: J. H. Barrett*)

Plate 28. Coffee stem showing scar remaining after ring-borer attack. (*Photo: J. H. Barrett*)

The urgent need for the eradication programme was highlighted by the discovery of alate nymphs in an advanced stage of development in almost all the larger colonies. It was, of course, highly desirable that the programme should be well advanced before flight could take place. It was estimated that this would probably occur at any time from February onwards. Accordingly, light-trapping with mercury vapour lamps was initiated on the site of the worst infested area. This was commenced in January and continued until May with completely negative results. It is assumed that the alates were destroyed before they matured, particularly as it was noted that towards the end of the eradication campaign they were congregating at or near ground level and would have been among the first individuals affected by the treatment.

In order to check the effectiveness of the eradication measures a series of pine 'cores' were placed in the treated areas, buried to a depth of 18 inches. These were designed to serve as traps for any undiscovered colonies or remnants of colonies which may have been broken up or scattered during the cleaning-up process. Inspection of these traps was to be carried out at three-monthly intervals until a decrease in the amount of infestation warranted an extension of the interval. Any traps found to be infested were removed, the area surrounding was trenched and treated with Dieldrin as before and an effort was made to locate the source of the infestation.

After three inspections, ten post traps were found to be infested out of a total of almost six hundred examined. This allowed the treatment of eight small pockets of infestation and, up to the end of June 1962, it was estimated that approximately 75 per cent. of the original 44½ acres had had two successive inspections which showed all the traps to be free from attack.

Control measures were continued during 1962-63 with satisfactory results, although the insect has not yet been completely eliminated. Two large centres of infestation have been free for three inspections, and another has been free for two inspections, while another area has shown no termites present since the first eradication treatment. There were no reports of new outbreaks in the Lae town area during 1962-63.

Pine Termite

The termite *Coptotermes elisae* was increasing in pine plantings at Bulolo and Wau, and the insect showed signs of becoming a major pest. Logging areas and pine plantings were inspected by the Principal Entomologist accompanied by Mr. F. J. Gay, and control measures were suggested. These included treatment of colonies on the logging face as trees are felled, treatment of stumps after the clearing burn, and regular treatment of trees as they show infection in the plantation. These measures are not easy to apply and it will be some time before their effectiveness can be assessed.

Pine Weevil Borer

An appreciable build up of damage by the weevil *Vanapa oberthuri* occurred in pine plantings at Bulolo. Following survey by an entomologist, control measures were suggested, involving mainly the collection of adults and removal of badly infested trees. After nine months of these treatments the populations were greatly reduced.

Scolytid Borer

A scolytid borer (*Hylurdrectonus* sp.) caused a considerable amount of defoliation in a stand of young pine at Wau. The assumption that attack was centred in unthrifty trees growing in poor soil does not appear to be altogether correct. The outbreak was the first observed and the insect has now returned to a low level of population.

FOOD CROPS

The cabbage moth *Plutella maculipennis* caused widespread damage to crucifers in the Highlands, and was recorded in plague proportions in the Komitaru area at 7,500 feet altitude. It appears that the wasp *Horogenes*, introduced from Australia some time ago, failed to become established, although it was recovered in the field several generations after release.

Heliothis armigera was often sufficiently severe in crops such as tomatoes and soya beans to necessitate spraying. Damage to bananas by the larvae of a zygaenid moth was widespread in the Highlands, but it was usually brought under control in due course by indigenous parasites.

The army-worm *Prodenia litura* continued to cause severe damage in market gardens in Wau. The giant toad was introduced from Lae in the hope that it would prey on the larvae. The toad was slow to become established and although *Prodenia* numbers have decreased it is not known to what extent the toad was responsible.

Two species of sweet potato hawk moth (*Herse convolvuli* and *Hippotion celerio*) caused considerable damage to gardens in several areas of New Britain. Taro was subject to some damage by *Papuana laevipennis* in New Britain and in villages in the Astrolabe Range. Another species, *P. semistriata*, was noted damaging taro at Wewak.

Pastures

The armyworm *Spodoptera exempta* appeared to be increasing on various grazing properties in the Markham Valley. Although at present localised, should it become a problem the possibilities of biological control would need investigation. The same species is also widespread in the Highlands, occurring most commonly on Kikuyu grass and maize. It responds well to D.D.T. spraying. *Lepidiota vogeli* occurred sporadically in the Highlands. Trials at Aiyura indicated that Dieldrin dust at 4 lb. and Aldrin dust at 2 lb. per acre were effective for a year or more in protecting lawns and pastures.

Ornamentals

The poinciana moth *Pericyma cruegeri* continued to cause severe damage at Port Moresby. It was also recorded from the Gulf District, Morobe District, Wewak and the Gazelle Peninsula. At some of these places it appeared to prefer *Peltophorum* as a food plant. In the Gazelle Peninsula equally severe damage was caused to poinciana by two species of case moths, and to *Peltophorum* by a leafminer. The yellow pierid, *Catopsilia,* caused serious setbacks to more susceptible species of *Cassia.*

Several releases of *Trichogramma* were made in the Port Moresby area. No recoveries of the parasite were made from eggs of *Pericyma* or *Catopsilia,* although both were parasitised by a species of *Trichogramma* at Popondetta.

MISCELLANEOUS

Injury to Palm Frond Roofs

A limited investigation was made of damage to saksak (sago palm) roofs of native houses in the Maprik sub-district by the pyralid moth *Herculia nigrivitta.* It was found that increased damage occurred in houses in areas which had been sprayed in the course of the Malaria Eradication Campaign, as a result of the differential destruction of the principal natural enemies of the moth; these appeared to be mainly predators such as ants, lizards and spiders. It was suggested that the use of Gammexane bombs could help in keeping down the moth population and thus lengthen the useful life of the dwelling.

Weed Control

In view of the spread of lantana in various parts of the Territory, and particularly at Bulolo where infestation of the pine plantings could eventually cause considerable trouble, a further effort was made to introduce tested insects to control it.

To this end, two batches of the deltoid noctuid *Hypena stringata* were received from Honolulu during May. In all, about 400 pupae were received. The second batch all aborted on emergence, but the first batch began to emerge successfully the day after they were received and all had emerged two days later. The first eggs were observed 6 days after the first adults emerged and hatching commenced on the following day. Feeding was first noted as pinpoints of light through the leaf, the lower surface of which was eaten, leaving the upper epidermis intact. As the larvae developed, the leaves and flowers were completely skeletonised. Recovery of heavily-eaten rooted cuttings was noted to be particularly slow. After three days feeding the larvae became very active and dropped haphazardly from the leaves and within 48 hours almost all of them had disappeared, although most of them were only half grown. Decimation of breeding stocks in this manner is not uncommon and, in this case, was probably the result of overcrowding. As a result, from approximately 500 larvae only 4 adults were reared to commence the following generation. This proved sufficient to start off another generation of a size unlikely to be affected by overcrowding.

As starvation tests have been carried out on this species by the U.S.D.A. and the C.S.I.R.O., the only local crop tested was cacao, the larvae's reaction to which was completely negative. It is anticipated that batches of pupae will soon be available for release at Bulolo, where a strong stand of lantana is established. As the climatic adaptability of this species to the moderate Highlands is not known, it may be necessary to consider the introduction of one or more other species that have been established in Hawaii and Australia.

Spraying and Dusting Machinery

Motorized spraying units continued to be used at Keravat for cacao spraying, and gave satisfactory results. For spot spraying of cacao flushes on younger trees use was made of the Hatsuta pressurized knapsack spray fitted with a trigger release. These were suitable for use on cacao trees up to about 2 years old.

Trials were made to assess the amount of spraying material used to cover an acre under average conditions. Using normal misting conditions, the quantity varied from two to sixteen gallons per acre with a water-based spray and was consistently about 4 gallons with a distillate-based spray. Effectiveness of spray cover was determined by incorporating a fluorescent dye in the spray liquid and examining selected leaves under an ultra-violet lamp.

AGRICULTURAL CHEMISTRY

The Chemistry Section now operates from two laboratories at Port Moresby and one laboratory at Keravat. At the headquarters laboratory at Konedobu analyses of foliar material pertaining to nutrition studies and field trials are performed. As the section has the only facilities in the Territory for wide-scale chemical investigations, the chemists at the Konedobu laboratory fulfil the role of Government chemists by undertaking analyses on a wide range of samples received from other Government instrumentalities, industry and private sources.

The laboratory at Kila performs analyses on soil samples submitted from all parts of the Territory by soil survey officers and other agricultural officers in the field. Soil samples are also received from other government organisations, industry and private plantation interests. Where possible analytical results from soil analyses are used in conjunction with foliar data to diagnose crop nutrition problems.

The Keravat laboratory was re-opened during 1962-63 to undertake nutrition studies of cacao, coffee, coconut and Manila hemp. This laboratory is important as it enables research to be carried out in a locality where much plantation activity is centred.

As a result of improvement in laboratory facilities and recruitment of additional staff, the number of samples analysed in 1961-62 increased by approximately a thousand over the previous year, to a total of 2,763. In 1962-63 a total of 2,803 samples were analysed. In Table 119, a summary is given of the different types of material sampled.

TABLE 119. SAMPLES RECEIVED AND EXAMINED DURING THE YEARS 1961–63

Type of Sample	*1961–62*		*1962–63*	
	Received	*Examined*	*Received*	*Examined*
Kila Laboratory—				
Soils	1,053	1,214*	1,073	701
Konedobu Laboratory—				
Blood sera	0	0	211	211
Foliar material	1,111	1,111	1,821	1,350
Fertilizers, concentrates, and insecticides	22	22	7	7
Foods	85	85	33	33
Pastures and fodders	6	6	21	21
Produce	115	115	157	144
Toxicological	3	3	10	10
Waters	123	123	82	82
Miscellaneous	84	84	13	13
Keravat Laboratory—				
Foliar material	0	0	223	223
Produce	0	0	66	0
Miscellaneous	0	0	9	8
Total	2,602	2,763	3,726	2,803

* Includes samples received in the previous year.

A large proportion of the work of the chemical section is carried on in conjunction with other sections of the Department and many of the results of chemical investigations are referred to elsewhere in this report. More than 1,000 of the soil samples analysed were collected in surveys by the Soil Survey and Chemistry Sections and most of the plant samples were taken from fertiliser and other agronomic trials on the main economic crops. An essential objective in all scientific sections is constant critical examination of laboratory techniques and methods, while for plant analyses, sampling methods also are always under review. Thus in conjunction with routine analyses, much of the work of the section is aimed at relating analytical results more precisely to the requirements of adequate plant nutrition.

SOIL ANALYSES

Soil samples were received from all districts of the Territory and the distribution of the samples examined, by District and source, is shown in Table 120.

TABLE 120. DISTRIBUTION OF SOIL SAMPLES EXAMINED

District	*Source of Sample*				
	Private	*Survey Section*	*Other D.A.S.F.*	*Other Government*	*Total*
Bougainville	100	..	1	..	101
Central	45	60	25	15	145
Eastern Highlands	28	30	26	3	87
Gulf	6	45	..	..	51
Madang	81	..	..	1	82
Manus	5	..	..	..	5
Milne Bay	4	43	6	8	61
Morobe	23	51	6	42	122
New Britain	109	324	206	..	639
New Ireland	43	..	2	..	45
Northern	122	..	8	31	161
Sepik	..	..	61	1	62
Southern Highlands	..	8	..	..	8
Western	14	113	7	..	134
Western Highlands	..	208	..	4	212
Total	580	882	348	105	1,915

PRIVATE SOIL SAMPLES

Three hundred and thirty-seven soil samples received from 44 localities were analysed during the year 1961-62. Most of the samples were received

from a firm of agricultural consultants who required analyses for the diagnosis of nutritional disorders of plantation crops.

A total of 243 soil samples received from various localities in eight districts were analysed during the year 1962-63. One hundred and eleven of these were analysed in connection with a cocoa nutrition survey undertaken by the Chemical Section in the Northern District and referred to in the Plant Nutrition Studies section of this report.

SOIL SURVEY SAMPLES

During the two years a total of 882 samples were analysed in association with soil surveys. Notes on the chemical features of these soils are given below; further information on other aspects of the surveys is given under *Soil Survey*.

Sogeri

The analysis of sixty samples collected during the Sogeri survey indicated that the light clay loam soils of flat to gently undulating topography were of relatively low fertility, being poorly supplied with bases and of low available phosphate status, but they were deep and of friable texture and would be suitable for the planting of rubber. Only limited areas of soils of the undulating hills and steep ridges were found to be suitable for agricultural use.

Bamu River

Analyses were performed on eighty samples representative of the three main classes of soils. In general terms the soils were heavily leached and infertile, reflecting the effects of the high rainfall incidence in this region.

Bulldog

The analytical results of 39 samples indicated that all soils were of low fertility and only in the topsoil to a depth of 6 inches could the nutrient status be regarded as adequate. Below this depth the nutrient levels fell off rapidly, and as exchange capacities were found to be low, frequent fertiliser applications would probably be necessary to maintain agricultural production.

Bomai

The analyses of 25 samples indicated that with the exception of available phosphate the fertility status of the topsoil to a depth of 6 inches was good, while the sub-soil was heavily leached. The organic matter in the surface soil can be expected to decrease following cultivation, with a consequent decline in nutrient status. The soils of the Bomai survey area can be regarded as having only short term agricultural potential unless care is taken to conserve organic matter.

Wahgi Valley

Analyses were performed on an additional 42 samples collected in the Banz region of the Wahgi Valley. The Wahgi survey is the most comprehensive investigation undertaken by the Soil Survey Section, and over 600 soil samples collected during the course of the survey have been analysed. Owing to the high variability of these soils and the volume of determinations carried out, it will not be possible to interpret the chemical results until final classification of soil types and detailed descriptive maps are prepared.

An additional 362 soil samples collected in the Western Highlands District in order to determine the fertility status of plantation soils in a study of the nutrition of highland coffee included many samples from the Wahgi Valley.

Baiyer River

Analyses of 113 samples indicated acid to neutral soils of varying nutrient status. The soils formed where drainage development was poor were characterised by high organic fractions in the surface and heavily leached sub-soils. Where drainage was satisfactory the soils varied from moderate to above average fertility.

Jimi Valley

The analytical results obtained from sixteen soil samples indicated moderate fertility with a possibility of potassium being limiting in some cases and available phosphorus always low.

Ramu Valley

The eighteen soil samples collected came from areas which are frequently flooded, and from non-flooded areas. The soils subject to flooding were found to be of low exchange capacity and low in available phosphorus, but contained adequate levels of exchangeable cations and nitrogen.

The non-flooded soils, although low in phosphorus content, were richly supplied with organic matter, had very high exchange capacities, and were highly saturated with exchangeable cations. They were considered to be of high agricultural potential.

Lower Watut Valley

Twenty soil samples were collected from the two main soil types and all were found to be at or near base saturation. Analytical results indicated that except for low nitrogen content the fine textured soils were highly fertile. The likelihood of water-logging in certain areas may impede their development.

The coarser textured soils were found to have lower fertility although the exchangeable cation status was high. Both nitrogen and phosphorus levels were only moderate. Nevertheless as the coarse textured soils are free from water-logged conditions they may be more suitable for immediate development.

Toriu River

Analysis of forty soil samples indicated extreme chemical variability of these alluvial soils. They varied from heavily leached acid soils of low nutrient status to alkaline calcium-saturated soils wtih calcium carbonate throughout the profile. A group of slightly acid to neutral soils of high exchange capacity were found to have potential for cacao and coconut production.

West Nakanai

Analyses of 68 samples indicated a rapid decline of organic matter content, and as a consequence a decline in nutrient status, with depth. A number of profiles showed a reduction of approximately 50 per cent of available nutrients, exchange capacity, and organic matter in passing from the 0-1″ horizon to the 4-6″ horizon, emphasising the central role of the maintenance of organic matter in preserving the fertility of these soils.

Trans-Vudal

Analyses were completed on 22 soil samples collected from the loams and clay loams in the Trans-Vudal area. The loams occur on ridges and on flats where drainage is imperfect. They were found to be well supplied with exchangeable cations but nitrogen and phosphorus contents were only moderate. The clay loams, although poorly drained, were considered to be of high nutrient status although the nitrogen levels were only moderate.

Oriomo

The analyses of 21 samples collected during an inspection of the lateritic soils of the Oriomo region revealed that with the exception of magnesium all major nutrients were at low levels, and the soils are of low agricultural potential.

Milne Bay

Forty three soil samples were collected during an inspection in the Milne Bay area and the outstanding feature of the analytical results was the consistent high magnesium status which, associated with low to medium potassium levels, could induce potassium deficiency. Although nitrogen and phosphate levels were found to be low to medium, the high exchange capacities suggested that sustained agricultural production would be possible provided correct management practices were adopted and research undertaken to determine fertiliser requirements and the best methods of their application.

Inspections of Individual Blocks

Analyses were performed on 92 soil samples collected during inspections of individual blocks in the following areas—

Baimuru	..	Western District
Bupu River	..	Morobe District
Erave	..	Southern Highlands District
Gobari	..	Morobe District
Kilinwata	..	New Britain District
Koabu	..	Western District
Mabaduan	..	Western District
Oomsis	..	Morobe District
Pangalu	..	New Britain District
Ranoulit	..	New Britain District
Situm	..	Morobe District
Tavai	..	Central District
Vudal	..	New Britain District

OTHER DEPARTMENT OF AGRICULTURE SOIL SAMPLES

Analyses were completed on 348 soil samples received from Plant Industry Experiment Stations, Animal Industry Livestock Stations, and Extension Officers in the field.

The largest group of samples came from the soil exhaustion and rotation trials at the Lowlands Agricultural Experiment Station, Keravat. Analytical results from soils sampled at the thirteenth planting of the soil exhaustion trial plots indicated depletion of available potassium to levels which must be considered marginal, but other nutrients, although of changed status, appeared quite adequate. The superimposition of a fertilizer trial on this area has led to difficulty in interpretation of subsequent results.

Analytical results from samples collected from the food crop rotation trial have been collated and are at present in the hands of the Statistician.

Twenty samples collected from two samplings of a sweet potato maturity trial at Keravat were analysed, and results indicated a lowering of the exchangeable potassium levels during the growing period.

Fourteen soil samples collected from the cacao, coconut and rubber plots in the Brown River area were analysed, with a view to making recommendations which would lead to improvement in the growth of these crops.

Fifty samples were analysed for the Division of Agricultural Extension in connection with land use investigations in the Telefomin and Aitape areas. The soils were of alluvial and colluvial derivation and showed considerable variation in chemical composition. Where drainage systems were inadequate they were found to be acid in reaction, heavily leached, and relatively infertile. Soils formed under more favourable conditions were of moderate fertility with potassium and phosphate the nutrients most likely to be limiting.

SOIL SAMPLES FROM OTHER GOVERNMENT DEPARTMENTS

Thirty-three soil samples received from the Department of Forests were examined with a view to making recommendations for improving the growth of hoop pine in the Wau area. Samples were collected from three sites, which included a formerly forested area, an *Imperata* grass area, and a *Themeda* grass area. Forestry experience had demonstrated that best growth of developing pine trees was associated with the formerly forested areas and poorest growth was obtained on the *Themeda* grass area. Analytical results indicated that the fertility of the soils followed the order of growth performance in that the soils of the formerly forested area were the most fertile and that of the *Themeda* area the least fertile.

Analyses were performed on 31 soil samples collected in the Northern District by a member of the Geographical Department of the University of Sydney, who is investigating whether there is a scientific difference between soil types as recognised by the local people and to what extent different systems of agriculture affect the fertility of the soil.

Analyses were also made of soil samples collected by the Department of Forests in the Bulolo, Trans-Asaro and Brown River regions, by the Commonwealth Department of Works at Tapini, and by the Department of the Army at Area Command Headquarters at Murray Barracks, Port Moresby.

EXAMINATION OF LABORATORY TECHNIQUES AND METHODS

The present method of determining the cation status of the soil involves the measurement of exchangeable cations. This is a capacity measurement. It is also important in plant nutrition to determine the intensity by which cations are held in the soil. To this end a method for determining ratios of activity of cations in the soils was investigated. The results may be expressed as a ratio such as pK : $\frac{1}{2}$pCa where values of 1.6 may indicate that potassium can be inducing calcium deficiency while values to the order of 2.6 may indicate that calcium can be inducing potassium deficiency. To obtain soils giving the range of 1.6 to 2.6, samples from various field trials and other investigations were analysed. Results ranging from 2.4 to 2.6 were obtained in soils from the exhaustion trial in progress at Keravat, suggesting that potassium may be deficient. One of the difficulties in interpretation of the soil chemical data obtained from this trial has been that although tuber production has fallen off markedly, soil nutrient levels have remained quite adequate for normal growth, although potassium status has been reduced to a marginal level. The activities ratios may emphasise the fact that although a cation may be present in adequate quantities, it is not necessarily available for absorption by the plant.

Ratios of approximately 1.4 were obtained from a plantation in the Talasea region, New Britain District, where investigations were undertaken to determine possible causes of a die-back condition. The low ratio may be interpreted to indicate that potassium levels are inducing a calcium deficiency. The method was also used to follow the levels of potassium in the sweet potato maturity trial at Keravat, and indicated a decrease in exchangeable potassium at the second sampling. Results to date suggest that changes in the quantity of exchangeable ions can be followed as the method approximately measures the actual activity ratios of certain ions in the soil, and it may well be a better measure of nutrient availability to the plant than the determination of exchangeable ions. Further investigation and development of the technique are intended.

PLANT NUTRITION STUDIES

The samples analysed during the two years are shown in Table 121.

TABLE 121. PLANT NUTRITION SAMPLES ANALYSED
1961–63

Nature of Sample	Number Analysed	
	1961–62	1962–63
Konedobu Laboratory—		
Cacao leaves	62	164
Cashew leaves	3	0
Coconut: buttons	9	0
fronds	55	8
husks	1	0
waters	33	29
Coffee leaves: (*Coffea arabica*)	613	1,066
(*C. canephora*)	14	3
Corn plants	66	0
Crotalaria leaves	2	0
Grass	15	0
Leucaena: leaves	4	5
nodules	0	16
plants	28	20
Peanut leaves	0	9
Pineapple leaves	0	2
Rubber leaves	24	6
Sorghum leaves	16	0
Soybean leaves	2	0
Sweet potato leaves	111	0
Tea leaves	17	10
Teak leaves	24	0
Tomato plants	6	0
Tomato roots	6	0
Miscellaneous	0	4
Nutrient solutions	0	8
Keravat Laboratory—		
Cacao leaves	0	223
Total	1,111	1,573

The increase in numbers of samples analysed (compared with 520 in 1960-61) could be attributed mainly to the large increase in coffee leaf samples, associated with an intensive investigation into coffee nutrition in the Highlands Districts of New Guinea. Other important projects were the analysis of sweet potato leaves from the Soil Exhaustion Trial at Keravat, and analysis of cacao leaves from fertilizer trials conducted by agronomists at Keravat. Plant samples, often in conjunction with soil samples, were collected and analysed also in connexion with specific problems in a wide variety of Territory crops.

In the field of crop nutrition, a main aim is to be able to use leaf analysis in the extension of the results of fertilizer trials to other areas. Coffee trials are limited to three areas in the Highlands, cacao trials to two areas of volcanic ash soils in New Britain, and coconut trials to New Ireland, New Britain, and the south east coast of Papua. Chemical analysis of foliar material may be the most satisfactory method of relating the nutritional status of crops growing in other areas to the status of the plants in the fertilizer trials, so that firm recommendations can be given for fertilizing.

Nearly all samples were analysed for nitrogen, phosphorus, potassium, calcium and magnesium, while sulphur determinations were made on some.

NUTRITIONAL STUDIES ON *COFFEA ARABICA*

The general purpose of this work was to be able to assess the nutritional status of coffee plantations by the use of foliar analysis, thus diagnosing nutritional problems and advising on correct fertilizer use. Results should also assist in interpreting the yield data obtained in agronomic trials. The method of approach was to collect and analyse leaf samples from the various fertilizer and other trials currently proceeding in the highlands in order to study—

(a) General nutritional status of the trial areas.

(b) Variation of leaf content with leaf position.

(c) Seasonal variation of leaf content.

(d) Effect of fertilizers on leaf content and the association with growth and yield responses.

(e) Effect of cultural practices, e.g., shade, pruning, spacing, mulching, varieties, &c., on leaf content.

(f) Association of leaf symptoms with leaf content.

(g) Relations between the individual nutrients in the leaves, particularly the effects which a deficiency of one nutrient may have on the uptake of others.

A large amount of work in other countries, particularly South America, on leaf analysis of coffee has defined the normal leaf levels to fairly narrow limits, and workers have also standardised on sampling the third or fourth leaves. Their conclusions have been tentatively applied to New Guinea conditions until enough data have been accumulated for modification if necessary.

Analyses were carried out on samples collected from the trials every month or in some cases every three months. The results indicate the general nutritional status of the particular trial and also the variation in leaf content over the season. When significant yield differences occur in a trial, their relationship with leaf analysis figures from control and fertilized plots is examined. As there are a

number of fertilizer trials in progress in the Highlands in different areas of varied nutritional status, much information on normal and deficient levels of nutrients is being obtained. These results can ultimately be applied to all other coffee growing areas, with due regard to factors such as shading.

Considerable progress has been made in this work and the main analytical findings are described below. Further details of the individual trials referred to may be found in the report of the Highlands Agricultural Experiment Station, Aiyura.

Omission Trial, Aiyura (ACA4)

This diagnostic trial has been proceeding since 1959. Leaf sampling at intervals of three months was commenced in November 1961.

Preliminary results showed a marked deficiency of potassium in the minus K treatment, and absorption of potassium in the potassium treated plots had been insufficient to bring the leaf potassium levels to a normal figure. It was therefore recommended that potassium applications be doubled. This was done in 1962, and the leaf levels have considerably increased.

An important consequence of low potassium uptake is the increase in magnesium content of the leaves. Potassium and magnesium have been found to be inversely related in all areas. The effect of the fertilizer applications on the potassium and magnesium levels of the leaves is well demonstrated in Table 122.

TABLE 122. OMISSION TRIAL (ACA4)
FOLIAR POTASSIUM AND MAGNESIUM LEVELS

Sampling Date	*Per cent. K in leaves*		*Per cent. Mg in leaves*	
	K Treatments	*Complete −K*	*K Treatments*	*Complete −K*
November 1961 ..	.61	.41	.52	.73
March 1962 ..	1.17	.66	.59	.76
July 1962 ..	.83	.43	.72	.95
October 1962 ..	.90	.57	.49	.80
January 1963 ..	1.25	.56	.42	.74
April 1963 ..	1.42	.61	.49	.97

Fertilizers are added in April and November each year. Following a doubling of the potassium rates, the leaf potassium levels have now approached the generally accepted standards of adequacy i.e. 1.6 to 2.0 per cent. K.

Average yields of the — K plots were lower than for any other treatment, although up to March 1962, the differences were not statistically significant. It is considered that previous applications have been insufficient and that with the increase in the potassium rate significant results will soon be obtained. Moreover the low potassium status throughout the experiment may mask the effects of other omitted nutrients.

Three other possible effects of consequence are noticeable in the results so far obtained.

(i) There appear to be higher leaf potassium levels in the wetter part of the year (November to May), and a higher uptake of potassium in the treated plots during that period.

(ii) The results in Table 122 show consistent figures for leaf potassium in the — K treatments, despite the plots being small and unguarded, and thus do not indicate much poaching from other fertilized trees.

(iii) There has been an uptake of nitrogen into the leaves of nitrogen treated plots soon after application of fertilizer, as demonstrated in Table 123.

TABLE 123. OMISSION TRIAL (ACA4)
FOLIAR NITROGEN LEVELS

Sampling Date	*Per cent. N in leaves*	
	+ N plots	*− N plots*
November 1961	2.31	2.33
March 1962	2.86	2.68
July 1962	2.80	2.71
October 1962	2.61	2.51
January 1963	2.72	2.44
April 1963	2.79	2.78

In general the nitrogen leaf contents are below normal for part of the year and some increase in yield due to nitrogen could be expected here.

High Level Fertilizer Trial, Aiyura (ACA7)

One replicate of this trial is on a grassland soil and the other on a pit-pit soil.

Regular monthly leaf sampling was commenced in May 1962, and results of the analyses are most illuminating. When treatment results are averaged, a small uptake of potassium with the lower rate of application, and a large uptake with the higher

rate, are clearly demonstrated. The K-Mg relationship is again very obvious. Table 124 shows the leaf contents of K and Mg for the three K levels of fertilizer.

TABLE 124. HIGH LEVEL FERTILIZER TRIAL, AIYURA (ACA7)

FOLIAR POTASSIUM AND MAGNESIUM LEVELS

Sampling Date	Per cent. K in leaves			Per cent. Mg in leaves		
	K_0	K_1	K_2	K_0	K_1	K_2
November 1961	.54	.52	.67	.94	.86	.67
March 1962 ..	.64	.74	1 28	.98	.88	.67
June 1962 ..	.52	.72	1 04	.89	.71	.54
July 1962 ..	.54	.74	1 01	.82	.73	.67
August 1962 ..	.63	.77	1 05	1 00	.83	.65
September 1962	.46	.69	.86	.81	.82	.67
October 1962 ..	.53	.57	.75	.74	.62	.55
November 1962	.52	.46	.63	.76	.62	.55
December 1962	.44	.44	.65	.69	.63	.55
January 1963 ..	.65	.80	1 01	.76	.61	.54
February 1963 ..	.93	1.05	1 38	..	..	..
March 1963 ..	.68	.85	1.19	..	..	..
April 1963 ..	.55	.70	1.22	..	..	..

These figures also show that the levels of potassium application (1 cwt. and 3 cwt. KCl per acre per annum) are insufficient to raise the leaf levels to normal and, in fact the low application has had little effect at all. Moreover, it would appear that the frequency of fertilizer applications should be increased, as the levels of the treated plots in November 1961 and November 1962 (i.e. just before fertilizing) are very low indeed.

As in ACA4 there is evidence that the uptake of potassium as measured by the amount in the leaves is higher in the wet season than in the dry, and the general levels in the control plots also follow this pattern.

There are no other major effects evident yet in the extensive results accumulated from this trial. There would appear to be a small uptake of nitrogen in the nitrogen treated plots, but this effect is not strong as potassium is the more limiting nutrient.

Records of this trial show a significant increase in yield of K_2 over K_1 treatments. All fertilized plots have yielded much more than the unfertilized controls and although the design does not permit elimination of a nitrogen and phosphorus effect, the analyses indicate that the major part of the response is due to potassium.

Fertilizer Trial, Aiyura (ACA16)

This is a new trial on hillside soil at Aiyura. The experiment is unshaded, in contrast to the others described in this report. Leaf samples were collected before the commencement of fertilizing so that adequate pre-treatment figures were obtained. Since then periodic sampling and analysis at three-monthly intervals has been carried out.

The pre-treatment sampling during the wet season showed a fairly good status of all major nutrients but since then the pattern has changed and there are strong possibilities of yield increases from any of the added nutrients. There is good evidence of uptake of both nitrogen and potassium and in general the samples from the phosphorus treated plots contain more phosphorus than the non-treated. The potassium content of the leaves from the plots without potassium is now well below normal, and yield differences due to potassium should be obtained.

The average leaf contents of nitrogen, phosphorus and potassium for the five samplings are shown in Table 125. Fertilizer was first applied in April, 1962, and applications repeated every six months.

TABLE 125. FERTILIZER TRIAL (ACA16)

FOLIAR NITROGEN, POTASSIUM AND PHOSPHORUS LEVELS

Sampling Date	Per cent. N				Per cent. K			Per cent. P	
	N_0	N_1	N_2	N_4	K_0	K_1	K_2	P_0	P_2
March 1962 ..	3.06	3.03	3.13	3.11	1.70	1.80	1.90	.143	.140
July 1962 ..	2.50	2.53	2.67	2.72	1.30	1.51	1.55	.110	.110
October 1962 ..	2.39	2.43	2.58	2.61	1.01	1.15	1.25	.100	.110
January 1963 ..	2.56	2.69	2.86	3.04	1.30	1.57	1.56	.137	.145
April 1963 ..	2.69	2.78	2.87	2.83	1.04	1.41	1.49	.115	.127

Nitrogen-Sulphur Trial, Aiyura (ACA28)

This experiment is primarily a diagnostic trial for sulphur deficiency, at two levels of nitrogen applied as urea.

Samples of leaves were examined before the commencement of fertilizer application. The average potassium level was low but there was marked variation between plots, ranging from 1.89 per cent. (normal) to 0.51 per cent. (very low). A basal potash dressing was therefore advised but this has been insufficient to raise the status of the poorer plots to a satisfactory level. It could be expected therefore that the variation in potassium status would cause a great deal of yield variation between plots, so that nitrogen and sulphur effects would have to be very strong to produce significant yield differences.

Since the commencement of the trial there has been an uptake of nitrogen in the treatments which include urea. There is also a tendency for the plots receiving gypsum applications to have lower nitrogen contents. The magnesium contents of leaves from all plots have been consistently above normal.

It is intended to determine the sulphur contents of leaves from this trial during the coming year.

High Level Fertilizer Trial, Goroka (ACA21)

This trial is sited on a deep, well-drained tropical red loam.

Leaf samples have been collected every month. Consistently normal leaf contents of nitrogen, phosphorus, potassium, calcium and magnesium have been obtained throughout the year. There has been a small uptake of nitrogen and potassium into the leaves of plots treated with N and K fertilizers, but as the non-treated plots are not low in content, yield responses from these nutrients are unlikely.

Shade x Spacing x Pruning Trial, Goroka (ACA 19)

This trial is situated alongside ACA21 on the same soil type.

Two series of samples were collected to show any effects on leaf content of different combinations of shade, pruning and fertilizing.

The only effects noticeable were a difference in nitrogen content in the no shade treatment and evidence of an uptake of nitrogen from the compound fertilizer in the no shade plots. The no shade unfertilized plots had typical nitrogen deficiency symptoms while in fertilized plots the symptoms were not so obvious. It is considered that for this area shade removal without associated nitrogenous fertilizing may have adverse effects on growth and yield.

High Level Fertilizer Trial, Korn Farm (ACA25)

This trial is laid down on a deep pit-pit soil.

Leaf samples have been collected every month for a year. All nutrients except potassium are in satisfactory supply; the K content of the control plots is intermediate between levels in the control plots of the corresponding trials at Aiyura and Goroka and thus considerably below normal. There have been rather large variations in K content of leaves throughout the season, but in no month have the control plot values reached a normal level. There has been a large uptake following application of fertilizers and in general the K_2 (3 cwt. KC1) and K_3 (5 cwt. KC1) treatments have maintained the leaf content at a satisfactory level. The level for the K_1 treatment (1 cwt. KC1) has ranged from well below normal (1.16 per cent.) to normal (2.02 per cent.) so this rate of application appears to be below the optimum.

No yield responses have yet been recorded for potassium in this trial but there is a large increase in yield of the NPK treatment over the control and this is probably largely due to potassium.

The effect of the high level K treatments has also been a lowering of the Mg content of the leaves and in some cases this level has dropped to what is considered a low figure. Thus overfertilizing with potassium may induce Mg deficiency. There is a tendency for the minus Mg plots to have a lower Mg level than the plus Mg plots and, as the former all have the high K treatment, there is a good possibility of yield depression.

Tables 126 and 127 demonstrate the uptake of K and the effect on Mg contents.

TABLE 126. HIGH LEVEL TRIAL, KORN FARM (ACA25)
FOLIAR POTASSIUM LEVELS

Sampling Date	*Per cent. K in leaves*			
	K_0 *treatment*	K_1 *treatment*	K_2 *treatment*	K_3 *treatment*
December 1961 ..	1.34	1.74	2.14	2.09
May 1962 ..	1.14	1.71	2.12	2.21
June 1962 ..	1.21	1.59	1.84	1.96
July 1962 ..	.98	1.26	1.52	1.74
August 1962 ..	1.36	1.82	2.25	2.27
September 1962 ..	1.01	1.30	1.80	1.92
October 1962 ..	1.32	1.85	2.50	2.51
November 1962 ..	1.00	1.38	1.70	1.86
December 1962 ..	1.09	1.29	1.68	1.78
January 1963 ..	1.30	1.57	1.87	1.97
February 1963 ..	1.47	2.02	2.44	2.60
March 1963 ..	1.03	1.89	2.44	2.46
April 1963 ..	.81	1.32	1.82	1.95
May 1963 ..	.82	1.16	1.43	1.91

TABLE 127. HIGH LEVEL TRIAL, KORN FARM (ACA25)

FOLIAR MAGNESIUM LEVELS

Sampling Date	Per cent. Mg in leaves			
	K_0 treatment	K_1 treatment	K_2 treatment	K_3 treatment
December 1961 ..	.95	.63	.46	.40
May 1962 ..	.93	.60	.40	.40
June 1962 ..	.75	.43	.28	.29
July 1962 ..	.86	.57	.38	.37
August 1962 ..	.62	.68	.49	.43
September 1962 ..	.64	.46	.33	.42
October 1962 ..	.76	.57	.40	.39
November 1962 ..	.80	.45	.32	.33
December 1962 ..	.89	.54	.35	.32
January 1963 ..	.75	.53	.39	.39

Study of Variation in Leaf Content with Leaf Position

A study has been made on this variation by sampling and analysing three areas, two of *Coffea arabica*, at Aiyura, and one of *C. canephora*, at the Brown River. The results of the analyses are set out in Table 128. The general conclusions regarding the trends for the different nutrients are as follows:—

Nitrogen: This nutrient is highest in the youngest leaves, then reaches a fairly constant figure at the third leaf position. The selection of the third leaf for a sampling procedure offers good differentiation between low and high nitrogen areas.

Phosphorus: This element generally increases with age of leaf for *arabica* but has the opposite trend with *canephora*. This is likely to depend largely on conditions of supply as there are large variations in P in the third leaf throughout the year. Further samples will be examined to confirm results.

Potassium: Values are fairly consistent throughout but there is a tendency for higher values in the youngest and oldest leaves with intermediate values in between. Comparison of the two arabica samples shows bigger differences at the older leaf positions than at the third leaf.

Calcium: C. arabica shows a definite tendency for increased calcium in the older leaves. In *C. canephora* this tendency is very strong, the calcium in the sixth leaf being three times that in the first.

Magnesium: Under conditions of adequate supply, the magnesium content in *C. arabica* leaves varies little. When magnesium is deficient, the element is apparently withdrawn from the older leaves, and they have a much lower content than the third leaves. Sampling of older leaves would therefore be better for diagnosis. In *C. canephora*, with good soil magnesium status the magnesium content increases with age.

In general it appears that while the selection of the third leaf as a general procedure may be satisfactory for diagnosis of deficiency, for some elements, e.g., Mg and perhaps K, the selection of older leaves may be preferable.

TABLE 128. EFFECT OF POSITION ON MINERAL CONTENT OF COFFEE LEAVES

(A) *Coffea arabica*, Aiyura, healthy leaves from K deficient area.
(B) *C. arabica*, Aiyura, trees showing N and Mg deficiency.
(C) *C. canephora*, Brown River, healthy leaves.

Leaf Position		1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Per cent. Nitrogen	(A) ..	..	2.90	2.65	2.69	2 63	2.62	2 62	2.59	2.60
	(B) ..	..	2.29	1.99	1.92	1.87	1.86	1.84	1.78	1.78
	(C) ..	3.88	3.22	2 86	2 89	2 82	2.78	..	..	..
Per cent. Phosphorus	(A) ..	..	.152	.159	.151	.160	.178	.191	.200	.217
	(B) ..	..	.160	.175	.205	.192	.227	.230	.247	.274
	(C) ..	.21	.17	.14	.12	.10	.14	..	..	..
Per cent. Potassium	(A) ..	..	1.10	1.02	.96	.90	.97	.93	.87	.98
	(B) ..	..	1.39	1.24	1.26	1.20	1.24	1.42	1.47	1.54
	(C) ..	2.04	1.72	1.57	1.40	1.16	1.64	..	..	..
Per cent. Calcium	(A) ..	..	1.01	.91	.87	.94	1.04	1.20	1.16	1.29
	(B) ..	..	.77	.77	.77	.93	1.06	1.14	1.18	1.18
	(C) ..	.82	1.19	2.39	2.63	2.03	2.73	..	..	..
Pet cent. Magnesium	(A) ..	..	.52	.45	.49	.45	.49	.54	.48	.48
	(B) ..	..	.29	.23	.20	.21	.20	.16	.14	.10
	(C) ..	.27	.26	.42	.43	.37	.48	..	..	..

Seasonal Variation in Leaf Content

In three highlands areas, viz., Aiyura, Goroka and Korn Farm, leaf samples have been collected every month and much information has been gained on the variation in chemical content throughout the year under conditions of low and high applications of fertilizer. It was necessary to estimate this variation in order to apply foliar analysis diagnostic procedures to samples collected at any time during the year.

As might be expected, the leaf contents of all nutrients were higher in the wetter parts of the year. Table 129 shows the range of variation obtained for these nutrients in the control (no fertilizer) treatments for the high level fertilizer trials.

TABLE 129. SEASONAL VARIATION IN MINERAL CONTENT OF COFFEE LEAVES

	Per cent. N	*Per cent. P*	*Per cent. K*	*Per cent. Ca*	*Per cent. Mg*
Aiyura—					
Highest value ..	2.95	0.19	0.93	1.00	1.00
Lowest value ..	2.62	0.14	0.44	0.69	0.69
Goroka—					
Highest value ..	2.96	0.20	2.08	1.27	0.49
Lowest value ..	2.49	0.14	1.69	0.80	0.33
Korn Farm—					
Highest value ..	3.40	0.20	1.47	1.53	0.95
Lowest value ..	2.73	0.14	0.81	0.84	0.62

Sulphur Nutrition in Coffee

Pot experiments carried out by Agronomists at Aiyura have confirmed that a sulphur deficiency exists in the area. Analytical work on sulphur has so far been confined to total sulphur contents and apparatus for the accurate determination of sulphate has not been available. An arbitrary method for "dilute hydrochloric acid extractable sulphur" was developed and found useful in differentiating the treatments in the sulphur pot trials. Thus the sulphur content of tomato plants as measured by this method average 1200 p.p.m. when treated with sulphur as against 200 p.p.m. when not treated. Coffee leaves from control and fertilized plots in the Aiyura trials also showed differences in sulphur content. Further work on sulphur nutrition in coffee is planned for next year and when new equipment arrives it is hoped to carry out sulphate sulphur estimations on a routine basis.

Coffee Nutrition Surveys

A start has been made on a systematic programme of soil and leaf sampling of coffee plantations throughout all the important coffee growing areas in the Territory. An officer of the Section has already spent a number of weeks in the Mt. Hagen district and visited all large plantations in the area. Details of plantations, such as shading, production, soil type, use of fertilizers, presence of nutritional disorders, drainage, pruning methods, etc., have been collected. This information, together with the analytical results, will provide a comprehensive basis for accurate fertilizer guidance for particular plantations.

CACAO NUTRITION

Systematic leaf sampling of shade and fertilizer trials at Keravat and a nearby plantation was begun during the year. The programme is concerned with nitrogen nutrition as both soil and leaf analyses indicate that other elements are in good supply. Its main aims are—

(1) To study the uptake of applied nitrogen under varying shade conditions.
(2) To determine how frequently fertilizer must be applied to maintain foliar nitrogen levels.
(3) To relate yield responses to leaf nitrogen content.
(4) To assist in interpretation of yield trends.
(5) To study seasonal fluctuations in leaf nitrogen content.
(6) To gain basic information so that foliar analyses may be used as a guide in making fertilizer recommendations for other plantations.

The tentative method of leaf sampling was to collect the third leaves of mature flushes at a time when the next flush was about to emerge. In practice it was found that this was not always possible, and further study will be made of sampling technique. In all cases samples consisted of 40 leaves from at least 8 trees chosen at random in each plot. Results of some of the analyses are shown in Tables 130 and 131, but trends are not yet clear. The fertilized trees generally had higher foliar nitrogen levels than unfertilized, and shaded trees higher than unshaded, but more data will be required to explain the fluctuations between different sampling dates.

TABLE 130. FERTILIZER TRIAL ON INTERPLANTED CACAO-COCONUTS (KTC9)

NITROGEN LEVELS IN CACAO LEAVES (PER CENT.)

Sampling Date	*Fertilizer Treatment*		
	N_0	N_1	N_4
16.11.62 ..	1.83	1.98	2.11
7.12.62.. ..	1.72	1.82	1.94
18.1.63.. ..	1.81	1.88	1.99
4.4.63	1.94	2.03	2.31
19.4 63.. ..	1.89	2.04	2.16
10 5.63.. ..	2.01	2.09	2.22
31.5.63.. ..	1.92	2.01	2.16
25.6 63 . ..	1.79	1.83	1.99

All figures are averages from 6 plots.

TABLE 131. SPACING x SHADE x NITROGEN TRIAL, KERAVAT (KTC3)

NITROGEN LEVELS IN CACAO LEAVES (PER CENT.)

Sampling Date	*12 ft. Spacing*				*15 ft. Spacing*			
	No Shade		*Shade*		*No Shade*		*Shade*	
	N_0	N_1	N_0	N_1	N_0	N_1	N_0	N_1
16.11.62..	1.89	2.42	2 09	2 32	1 92	2 03	2 19	2.40
7.2.63 ..	2 06	2 34	2.28	2.26	2.11	2 42	2.36	2.42
4.3.63..	2.19	2.40	2.39	2.50	1.97	2 40	2.49	2.40
23.4.63 ..	2.12	2 38	2.32	2 46	1.96	2.26	2.37	2.40
31.5.63 ..	2.35	2.41	2.37	2 6[illegible]	2.06	2.30	2.36	2.53
24.6.63 ..	1.99	2 28	2.28	2.25	1.92	2.27	2.20	2.28

All figures are averages from 2 plots.

A comprehensive survey of representative plantations in the Popondetta-Sangara district was undertaken. Soil and cacao leaf samples were taken from 68 separate sites in the area and reports on the nutritional status of 23 plantations were issued. In general the survey showed a good fertility in the area, particularly in the Sangara section where there are few indications of any nutrient disorder. The Popondetta grasslands require careful management and are nitrogen deficient in some areas. In the older areas there are indications of a low potassium status in the soils and leaves. In one grassland area a definite sulphur deficiency in the *Leucaena* shade plants was confirmed.

Other cacao leaf samples from New Ireland, Bougainville and New Britain districts have been analysed.

Definite evidence that samples of leaves collected from trees with "die-back" have a low calcium content has been obtained, and the relation between calcium nutrition and the disease will be further investigated in the coming year.

COCONUT NUTRITION

Analysis of coconut water samples has continued as a routine diagnosis for potassium deficiency. Samples of coconut water and fronds from five areas indicated that potassium deficiency was probably not responsible for poor growth. Further frond samples from seedlings in fertilizer trials in New Ireland and Papua were analysed. Both experiments show uptake of potassium into the leaves of potassium treated plots. Pilot analyses on coconut "buttons" were also made, but they appeared to be more variable in chemical content than the leaves.

TEA NUTRITION

Following studies described in the 1960-61 Report, fertilizer trials were laid down at Garaina. The first was a nitrogen-sulphur trial involving various sources of nitrogen and sulphur. The second trial was designed to determine requirements of nutrients other than sulphur and had a basal dressing of sulphur on all plots.

The nitrogen-sulphur trial showed an immediate response in colour and growth to all S treatments.

Table 132 shows the combined weights of green tea leaf produced by the various treatments on this trial up to June, 1963.

TABLE 132. NITROGEN-SULPHUR FERTILIZER TRIAL ON TEA, GARAINA

YIELDS TO JUNE, 1963

Treatment	*Weight Green Tea*
	lb.
Control	295
Urea	222
Sulphur	498
Urea + sulphur ..	515
Gypsum	500
Urea + gypsum ..	575
Sulphate of Ammonia	502

The other fertilizer experiment has not yet shown any significant differences between treatments.

A marked marginal chlorosis occurring in older leaves of many trees in the plantation will be investigated during the coming year. There is a possibility that this is a toxicity of manganese or other metal induced by the highly acid soils of the area and if so it is likely to be aggravated by any acidic fertiliser such as sulphate of ammonia or sulphur.

MISCELLANEOUS STUDIES

The analysis of leaves sampled from coffee, cacao and rubber growing under deficient conditions in the glasshouse was completed and yielded interesting results. Deficiencies of nitrogen, potassium and phosphorus in these three crops were observed and analysis results associated with mild and serious symptoms, for these glasshouse conditions, were obtained.

In glasshouse experiments being carried out by the Microbiologist on the efficiency of *Leucaena glauca* inoculants, the analysis of the plants for nitrogen gave further information on the uptake of nitrogen and the efficiency of nodulation.

Samples of natural grasses from various paddocks at Yambi were examined. They all contained only very small amounts of calcium, phosphorus, potassium and magnesium, a reflection of the extremely poor fertility of the area.

Samples of teak leaves were taken from a mulching trial being carried out by the Forestry Department at their Brown River nursery. The area had previously been shown to be nitrogen deficient, but various thicknesses of mulch did not significantly affect the nitrogen content of the leaves in the plots.

Samples of cashew, soybean and *Crotalaria* leaves with and without leaf symptoms could not be differentiated by foliar analysis of the common major nutrients. Sulphur or micro-nutrient deficiences were suspected in these cases.

Leaf analysis of pineapples showing marked chlorosis confirmed nitrogen deficiency. Suspected deficiencies in rubber and various ornamentals were similarly confirmed.

Nutrient solutions used in a Port Moresby hydroponic installation were analysed to show the change in concentration and in pH over a period of a fortnight.

GENERAL AND INDUSTRIAL INVESTIGATIONS

AGRICULTURAL PRODUCTS

Cocoa Beans

Pod collections were made from the clone-testing blocks at Keravat and 156 samples were examined as a continuation of the programme commenced in 1957 to investigate various physical and chemical characteristics of the cocoa beans produced by the 60 clones being tested. Bean weight, moisture content, shell percentage, fat content, chemical constitution of the fat and other characteristics are being measured.

The initial objective is to determine a suitable sample size for assessing the pod to pod variation within and between trees of the same clone as well as the tree to tree variation between clones.

Pyrethrum

Thirty-seven samples of pyrethrum flowers were assayed for pyrethrin I and pyrethrin II content, using the A.O.A.C. mercury reduction method. The samples represented fourteen strains developed at the Highlands Agricultural Experiment Station, Aiyura, and selected for chemical testing following satisfactory agronomic performance. One of the strains, the cross 78/65 x 50, was planted out in observation plots at various Highland environments with altitudes ranging from 4,800-8,200 feet (*see* Table 105, page 107).

In general terms, chemical assays gave the expected result of significant increases in pyrethrins content with increase in altitude, but there were some exceptions. The exceptions may have been caused by micro-climatic effects associated with local topography rather than altitude, although a number of other factors such as seasonal variations, methods of drying and genetical segregation may have contributed towards conflicting results.

The spectrophotometric method of analysis for total pyrethrins has been investigated, and results comparable with those obtained by the mercury reduction method suggest that the former method will be quite suitable for the routine testing of large numbers of samples from the same strain.

Soya Bean

Thirty-seven samples of soya bean were received from variety trials established at the Highlands centres of Aiyura, Minj, Wabag and Laiagam. To date only the Aiyura and Wabag samples have been analysed. They showed wide variations in oil and crude protein content between varieties and within the same variety grown at the two localities.

Samples including soya bean, soya oil and soya bean cake from a small oil crushing installation established by a Mission in the Markham Valley were examined to determine the quality of the oil and cake and to assess the efficiency of the extraction process.

Other Produce

Other produce samples examined included vanilla beans, coffee, peanuts, tea, copra and castor beans. The castor bean samples were studied in conjunction with field trials at the Plant Industry Centre, Bubia. All other examinations were made to assist in quality assessment.

Pastures and Fodders

Eleven samples of the very palatable grass *Rottboellia exaltata* from the Moitaka Livestock Station and from the Plant Industry Centre, Bubia, were examined. High crude protein levels at pre-flowering and flowering stages confirmed results reported in the 1960-61 Annual Report.

Samples of lucerne from a limited observation trial at the Bubia Plant Industry Centre gave satisfactory results. Eight samples were analysed from another trial including *Phaseolus lathyroides* as well as lucerne.

Four samples including bêche de mer, sorghum, corn meal and soya bean meal were received from private sources.

FOOD

Most of the food samples analysed were received from Nutrition Research Teams. Proximate analyses were made on 34 varieties of sweet potatoes and 41 other foods, including peanut, peanut meal, soya bean, sunflower, taro, banana, maize, pumpkin, papaya, marrow, pit pit (*Panicum palmarum*), dried fish, and lentils, all from Kundiawa, and on 26 yam samples from the Maprik region. There was a wide range in protein values between the varieties and strains of yams grown in the region. A collection is being made of approximately 50 varieties so that a closer study of agronomic performance and nutritional value may be undertaken. Other samples examined included sago, opa and flour.

Analyses were also made of seven samples of tinned meat and seven samples of tinned fish to ensure compliance with the terms of the scale of rations under Native Labour Regulations or conformity to Stores and Tender Board Specifications.

MISCELLANEOUS

Blood Sera

A total of 211 samples of blood serum collected from cows at the Moitaka, Bisianumu and Erap Livestock Stations, were analysed for calcium and inorganic phosphate in conjunction with investigations by the Division of Animal Industry into low fertility levels in their herds. The animals sampled varied in age, lactation, oestral and pregnancy condition.

The chemical results indicated slightly higher calcium and inorganic phosphate levels in non-lactating cows, but failed to show that nutritional deficiency or dietary imbalance were contributing to low fertility.

Fertilizers, Insecticides and Concentrates

Analyses were performed on fifteen fertilizer samples to identify chemical constituents, and six fertilizer samples to determine efficiency of mixing techniques. One sample of bat guano from caves in the Eastern Highlands and two samples of flying fox manure from caves in the New Ireland District were too low in nutrients to encourage commercial exploitation, but nitrogen and phosphate levels were high enough to warrant local usage.

Four Dieldrin samples received from the Department of Public Health Malaria Unit were analysed in order to establish conformity with chemical specifications.

Waters

One hundred and thirty-nine water samples were received from the Commonwealth Department of Works in connection with a hydrological survey of the Territory's water resources. Other samples came from the Administration Departments of Health, Lands, Forests, Education, the Commonwealth Departments of Works and Civil Aviation, and the Army and private sources.

Toxicological

Ten samples of hair dyes received from the Department of Public Health were examined for prohibited dyestuffs. Only one sample was found to be free of prohibited ingredients and the others were placed on the list of prohibited imports.

Following complaints from consumers, a sample of rice taken from a shipment from the Northern Territory of Australia was examined to determine whether any harmful contaminants might be present. It was found to be free from harmful substances.

Other substances examined were a powder exhibit submitted by a Native Affairs Court enquiring into the death of a baby, and an acid exhibit to the Supreme Court.

Other

Other samples received included filter alum for the water treatment works at Bomana, shirts from the Stores and Supply Branch, transformer oil from the Electrical Undertakings Branch, apple cider from the Department of Trade and Customs, synthetic rice from overseas, and six samples of native-produced liquor submitted by the Chairman of the Liquor Commission.

CHEMICAL LIGHT METERS FOR SHADE MEASUREMENT

The possibility was investigated of using chemical lightmeters, in the form of tubes containing a solution of a photosensitive material, to measure shade in coffee plantations. Results from East Africa in experiments using solutions of anthracene in benzene indicated that this method could be very successful. A further method using aqueous solutions of potassium iodide was also investigated. It was found that when a 30 per cent solution of potassium iodide was exposed to the sun, iodine was formed by decomposition and the resulting amount could be readily determined colorimetrically. When different bottles were exposed to varying light intensities it was found that there was a definite relationship between the amount of iodine produced and the amount of light producing it.

Both methods were employed in field tests at Aiyura. The bottles containing the photosensitive solution were supported by small wire cradles which were suspended between the shade trees on the coffee block. By this method, over a hundred bottles, distributed evenly over a block, were exposed for a daily period while at the same time a set of bottles under standard shades was also exposed. The amount of light penetrating the shade canopy was estimated for each site and by average the amount of shade over the whole block calculated. There was close agreement between the two methods and both offer promise for measuring shade on coffee experimental blocks.

The anthracene method seems to be more accurate than the iodine method, but the difficulties of transporting large quantities of the solvent, purified benzene, to and from the field, limit its practical application.

SOIL SURVEY

During the two years, soil surveys were carried out in most districts of the Territory. The main investigations are described below. Spot investigations were also carried out as required in connection with land purchase, development, credit loans and soil problems.

WESTERN DISTRICT

BAMU RIVER

An exploratory survey of the Mt. Bosavi—Papuan Plateau volcanic complex was made in the area between the Wawoi and Turama Rivers in the eastern sector of the Western District. The survey was mounted in conjunction with geologists investigating possible bauxite potential, and forestry officers, and covered an area of 400 square miles north of Komewu on the Bamu River to the lower slopes of Mt. Bosavi, where fast rapids become the upper limit of navigability by canoes.

Three main physiographic zones were defined within the area, viz:

(a) Mt. Bosavi and the ridges emanating from the crater.

(b) Deeply dissected undulating ridges of tuffaceous sandstones formed partially under an aqueous environment.

(c) Senile low lying undulating land developed on fine sandstones and siltstones deposited under an aqueous environment. This stretches south into the zone of recent alluvium.

The three strata form a flange-like succession, the northern volcanic layer being uppermost.

Three main soil classes were observed in the area, related to these geological zones—

Soils developed on basalts: These soils are slightly friable brown to reddish brown clay loams or light clays with fine subangular blocky structure. Faint yellow mottling was sometimes observed.

The soils are heavily leached, the vegetation is poor, and chemical analyses have indicated a low nutrient status. Small areas of skeletal soils on vesicular basalts occur in the surveyed portion, near the Wawoi River.

Soils developed from tuffaceous sandstones: These soils range from the well drained Bamu Series to the poorly drained Kimu Series. They are normally shallow grey brown loams overlying grey brown mottled clays of firm consistency. Erosion is active in the better drained ridge soils.

Soils derived from fine grained sandstones and siltstones: These soils are, on the whole, poorly drained, and subsoils are usually plastic massive clay with prominent grey and yellow brown mottling.

The area is one of the wettest in Papua with over 200 in. rainfall per annum and this is reflected in both the physical and chemical characteristics of the soil. The topography is very broken and limiting for any extensive agricultural development. The potential for agriculture or forestry is low and costs in such an isolated area would be extremely high.

GULF DISTRICT

MURUA RIVER

A detailed survey of 5,800 acres in the Murua River area near Kerema showed 1,880 acres to be suitable for sub-division into small rubber holdings. The bulk of the agricultural country comprises undulating to hilly areas of silty clays derived from mudstones. These are red ochre clays which on wetting turn irreversibly to light or medium brown clays which proved to be superplastic. The remainder of the land is either swampy or else comprises narrow levees which are too limited for agricultural development.

BULLDOG

An area of 9,000 acres of lowland alluvials in the Bulldog area was investigated. About half is suitable for development for planting coconuts and gardening, and over a thousand acres is suitable for rubber. The soils most suitable for rubber are brown and yellow clays developed from conglomerates of the northern hills. The bulk of the area is covered by recent coarse-textured soils with minor areas of finer silts. Forest potential is low.

EASTERN HIGHLANDS DISTRICT

BOMAI

Eighty square miles of country was examined in the Bomai area which lies in the south western corner of the Eastern Highlands. The soils are highly leached humic clays of low overall fertility and support a low forest cover.

The Bomai land system is essentially a gently sloping apron to the south of Mt. Au, a Pleistocene volcano. The soils developed on a deep agglomerate of basaltic and vesicular laval rocks and boulders in an andesitic ash matrix, are all very uniform, deep, friable, dark brown clays. However, there is high chemical fertility in the top few inches only, and the subsoil is heavily leached of the bases calcium, magnesium and potassium. The soils are acid, pH 5.5-6.0. Shading and mulching would be required to maintain a high level of organic matter while access to the area would prove a limiting factor for development.

ERAVE

A survey was made of a valley of 1,000 acres east of Erave. The valley is of volcanic origin and consists mainly of consolidated ash deposits derived from Mt. Murray, a Pleistocene volcano. The soils in the area tend to be relatively shallow and topsoil development is limited. The main soils within the area, the Kini Soils, were intrazonal hydromorphics developed from consolidated ash parent material.

Two more soil types were recorded in a reconnaissance of the Erave-Samberigi area to the south of Erave and near the north-west slopes of Mt. Murray. Both Widoro and Yahara soils are brown humic latosols developed on fine-grained volcanic rock and ash. As with the soils of the Bomai area it is apparent that fertility is totally dependent on maintenance of the organic matter.

WESTERN HIGHLANDS DISTRICT

WAHGI VALLEY

The first phase of a base survey of the district was completed. Reports were submitted on the three main swamp areas viz. the Gumants-Kugimi (24,450 acres), the Pin-Tumen (35,000 acres), and the Tumen-Banz (64,000 acres).

The three areas together cover a section of valley stretching from the eastern end of the Mt. Hagen ash shield through the very wet peats of the Kugimi basin and further east for about 20 miles through increasingly drier old lake bed deposits towards Banz. The Wahgi river becomes more deeply entrenched as it flows east and overall valley drainage depends on the degree of entrenchment. The altitude of the valley floor is about 5,200 feet and rainfall varies from 80 to 100 inches.

Gumants-Kugimi Swamp

The area is drained by the two named streams and is predominantly very wet and subject to surface flooding by runoff from the adjacent hill slopes.

The survey was designed to provide detailed information regarding the feasibility of, and potential for, drainage. The report classed soils in five categories according to drainage feasibility, viz—

(a) Soils requiring little or no artificial drainage for crop production.

(b) Soils which could be drained as separate entities without major earth works.

(c) Soils which could be drained only on a large scale and which are not excessively peaty.

(d) Soils which could be drained only on a large scale and which are excessively peaty.

(e) Soils which are not drainable or which could be drained only with excessive difficulty.

The soils were also divided into three subclasses according to limitations on use, viz.:

(i) Soils with no apparent serious physical limitations to crop growth.

(ii) Soils with subsurface horizons of a type likely to impede root penetration and disturb water relations and aeration.

(iii) Soils subject to flooding from adjacent streams.

Class (a) soils cover 2,600 acres and are mainly latosols developed on andesitic ash, or alluvials derived mainly from the volcanic shield. The latosols are yellow brown friable clays; the alluvials, brown and grey loams to sandy clays. Subsurface concretionary layers in a number of ash alluvial soils were considered limiting to root growth and the two series involved were considered to fall in subclass (ii). One series of recent silts found on the present flood plains falls into subclass (iii).

Class (b) soils (1,900 acres) are typically found scattered on lower hillside fans where seepage from the steeper slopes above causes a wet condition that could readily be improved. Soils are characteristically hydromorphic, with fine-textured grey mottled subsoil under organic medium textured topsoil. Where the subsoil consistency is plastic to very plastic and likely to impede aeration the soils have been considered to fall in subclass (ii).

Class (c) soils (10,600 acres) occupy the valley floor where drainage could be undertaken only over a wide area regardless of individual soil characteristics. These soils were considered to have a high potential for drainage and recommendations for draining were presented. The soils are peaty in the surface and usually highly organic clays in the subsoil, and support a *Phragmites* reed dominant vegetation.

Class (d) soils (3,700 acres) are more peaty throughout than those of the previous category and while reclamation was recommended, more care would be necessary to avoid excessive shrinkage.

Class (e) soils (2,600 acres) are deep peats broken by stretches of open water found in the lowest part of the valley, and are considered unsuitable for immediate development.

The establishment of trial plots on representative soils was recommended before large scale reclamation.

Pin-Tumen Swamp

The area is drained by the two named streams that rise in the southern valley wall and flow into the Wahgi river, which at this stage has one distinct terrace. Extensive swamps have developed where small streams emerge from hillside gullies but the proportion of open water swamp is less than in the Gumants-Kugimi basin.

Again emphasis was placed on drainage potential and the report considered soils in six classes, viz.—

(a) Moderately well to well drained soils not subject to inundation, mainly shallow shaley soils of the surrounding hills (11,850 acres).

(b) Somewhat poorly drained soils with a permanent intermediate water table, but not subject to surface inundation (4,850 acres). These were mapped as a number of complexes of grey clay soils often overlying deep gravel. The land is mainly used for pig foraging under native agricultural practice.

(c) Poorly to very poorly drained soils with a near permanent surface water table but not subject to inundation (10,000 acres). These again are deep grey fine textured soils usually with a pot-holey, highly organic, dark surface.

(d) and (e) Groups of soils similar to those of groups (b) and (c) but with peaty topsoils, and subject to periodic inundation to a depth of a foot or so by runoff from the surrounding hills. The largest area (5,100 acres) is made up of peaty soils in natural depressions on the valley floor.

(f) Very poorly drained peats almost always ponded or flooded (2,250 acres).

Tumen-Banz Area

The area covered lies to the west of the Tumen River on both north and south sides of the Wahgi as far east as Banz.

The general soil areas are related to topography in the following main classes—

(i) *Hills:* Typically the hill soils are comparatively shallow yellow brown and brown clays, in some cases distinctly skeletal, owing to accelerated natural erosion on the shaley slopes, which carry a short grass vegetation.

(ii) *Soils on the colluvial fans* are generally hydromorphic mottled clays overlying shaley clay at depth. The fans have developed extensively, possibly under lacustrine conditions, and the Aviamp series closely associated with them is an important soil for plantation and garden crops. The soil is slowly permeable but can be drained easily, and supports a short grass vegetation.

(iii) *Soils along flats above the Wahgi terraces* have developed from parent material derived from two different sources, either from the adjacent mountains as a result of erosion or water transport by creeks, or from the Wahgi river at a time when it was not entrenched as it is now to a depth of some 50 feet in this area. The soils derived from parent materials from the adjacent mountains are most extensive and are typically heavy clays to depth. Soils derived from deposition along the previous course of the Wahgi are, as a result of their more diverse origin, very variable in texture. All the soils are relatively deep. Many are poorly drained and the group includes some areas that are most distinctly waterlogged, often with a dense cover of *Phragmites*.

The most important single series is the Kigabah which displays physical characteristics similar to those of volcanic ash derived soils of the Korn series near Mt. Hagen. The topsoil is medium textured and is typically black, deep and very friable. The subsoil is an almost white clay underlain at depth by the extensive mottled shaley clay material of the fans.

(iv) *Soils of the present Wahgi terraces* are extremely variable and the majority are very wet and subject to flooding after small rises in the streams. The dominant vegetation is *Phragmites*.

Co-ordinated drainage is required over much of class (iii) and some class (ii) land to ensure effective channel location.

JIMI VALLEY

A reconnaissance survey was conducted in the Lower and Middle Jimi Valley. There is approximately 12,000 acres of grasslands and 10,000 acres of forested land suitable for agricultural development.

The surrounding ridges of the valley are acid igneous intrusives and within the basin itself there are igneous conglomerates deposited under lacustrine conditions. The area is similar to the Baiyer Valley in that river incision has resulted in the present drainage status and soils of the grass climax areas have a bleached B-C horizon. Laterization occurs in varying degrees throughout the whole of the valley.

The moderately well drained Ruti soils of the grasslands have a brown or grey brown loam topsoil ranging in depth from two to thirteen inches and averaging about six to eight inches. The subsoil is lateritic and is a grey mottled clay of weakly developed blocky structure. In the swampier grassland soil, the subsoil consists of grey clay pug.

The soils under the rainforest in the moderately undulating areas consist of friable red brown clay loams which have a very weakly developed medium subangular blocky structure. The degree of iron concretion development varies considerably and the general fertility of the soils is suspect.

MADANG DISTRICT

RAMU VALLEY

An examination of the more promising areas of the Ramu River valley was undertaken. This involved spot checks over 150,000 acres of land. Two important problems within the area are the base saturated character of the soils and the incidence and intensity of flooding. Further studies of these problems will be essential, but the resettlement potential of this sparsely populated region appears to be high.

MOROBE DISTRICT

LOWER WATUT VALLEY

An area of 2,700 acres at Maralinen on the Lower Watut River was surveyed and the soils found to be base saturated alluvials.

Almost 1,000 acres of coarse textured dark brown soil are suitable for coconuts while a further 1,000 acres of fine textured grey brown soils subject to seasonal waterlogging would require some degree of surface drainage for optimum use.

NEW BRITAIN DISTRICT

RANOULIT

A survey was made of a proposed resettlement area at Ranoulit in the New Britain District. The 1,455 acres is located in the lower foothills of the Bainings Mountains east of the Tavalue River. The country is broken and steeply undulating with only 680 acres not marginal or limiting for agriculture. The area lies in the recent volcanic ash zone, but where the land is gently undulating the over-lying volcanic ash becomes much thinner, and the organic matter less, and on the narrow ridges the ash is non-existent. Igneous rock outcropping occurs in very steep areas in the northern and southern sectors. The buried profile is a firm reddish brown clay.

TORIU RIVER

An area of 23,600 acres was surveyed between the Toriu and Sambei Rivers in the North Bainings Subdivision, as part of a general programme of investigation of land resources in New Britain. The area is basically a broad alluvial plain in which concave and depressed areas tend to be swampy or subject to flooding. The ridges to the east are mainly of limestone derivatives but the geology and subsequently the alluvial deposits are very mixed, e.g. marls and pumice are present together.

At the first investigation carried out in the dry season it was recommended that a subsequent survey be undertaken to examine 4,100 acres of land deemed marginal due to flooding. This revealed that drainage would not be feasible and that only 3,650 acres had immediate potential for cacao or coconuts.

NAKANAI COAST

A rapid reconnaissance of the Nakanai Coast was made from Powell Harbour westwards. Alluvial soils covered with ash layers were observed at Matanakunai. Inland, ridges are of limestone or marl derivation. Coarse textured clinkery soils of recent origin occur around Mt. Ulawun, a volcano known as "The Father", which erupted in 1915. Further westwards the soils around Bubu and Bialla, although still of volcanic origin, are dark brown and medium to fine textured. They are more weathered and have lost the raw ashy appearance of those nearer Mt. Ulawun.

WEST NAKANAI

Four adjacent areas of land totalling 2,200 acres were investigated near Cape Hoskins in New Britain. The soils have developed from recent pumice

and ash and are of high agricultural potential for cacao and coconuts. Profile characteristics are complex and have been dictated more by alluvial resorting than by pedogenetic mechanisms. The soils are generally brown, grading to olive in the fresh pumice.

TRANS-VUDAL

A reconnaissance survey of 11,000 acres was conducted in the Vudal-Valilie river area of the Gazelle Peninsula. The soils are derived from recent pumice and show only juvenile development. On flat areas drainage is imperfect, but well drained areas are suitable for cacao and coconuts.

ATALIKLIKUN COAST

Adjacent to the Trans-Vudal, three areas of freehold totalling 9,000 acres were inspected to determine development potential. The better soils are juvenile yellow brown clays developing from recent pumice. Brown mottled clays have developed over pumice on flat lands with impeded drainage.

BAININGS AREA

Two areas were investigated in the Bainings area, the first on the north coast at Kamanakan and the second in the hills around the upper Toriu river valley at an altitude of 1,000 to 2,000 feet. Both were suggested as sites for possible consolidated resettlement of scattered Bainings people.

In the Kamanakan area, 2,800 acres of soils derived from recent pumice overlying deep clays developed from limestone and older ash, were found suitable for cacao, coconuts and gardening and the land is satisfactory for closer settlement.

In the upper Toriu Valley an area of 10,000 acres of soils, again derived from pumice overlying mainly limestone derived clays, is most promising. Brown clays are developing from the pumice which provides a cover of from 1½ to 4 feet over the underlying clay. Stiff reddish brown limestone-derived clay is exposed on steep hill sides.

INDIVIDUAL BLOCKS

Oomsis

A total area of 469 acres was investigated near Oomsis in the Morobe District of New Guinea. The area is in the main a stony narrow alluvial plain of the Oomsis Creek bordered by extremely steep ridges. The soils have developed on metamorphic rocks and rubble and phyllites are commonly found within the profile. An area of 122 acres was deemed suitable for agriculture but proved too attenuated for a satisfactory subdivision.

Pangalu

Pangalu land, comprising 900 acres, is located to the north of Talasea in the New Britain District. The soils have developed on volcanic ash and the main soil type present is a dark brown fine sandy loam overlying sandy ash at from 19 to 25 inches depth. A sub-division of 580 acres suitable for coconuts, cacao, and food crops was suggested.

INSPECTIONS

Inspections of individual plantations to assess development potential were made at Bialla and Kilinwata in New Britain; Libba in New Ireland; Ayomontina, Lucinora and Kundana in the Eastern Highlands; and Hagita at Milne Bay.

MISCELLANEOUS

Cacao Dieback Investigations

Studies of dieback areas of cacao were carried out on three plantations in the Talasea-Cape Hoskins area of New Britain. No factor was isolated as a precursor of *Botryodiplodia* invasion but it was concluded that a profitable approach would be a study of the rate of water movement through stratified volcanic ash soil and the state of aeration of the soil during a dry season and the following wet season.

Survey of Intensive Agriculture

Two inspections of survey areas in the Chimbu, Wabag and Maprik districts were made to examine soil and land classes prior to mapping these during 1963-64. The final field legend was prepared during the second visit.

DIVISION OF EXTENSION AND MARKETING

In carrying out the functions outlined above under *Department of Agriculture, Stock and Fisheries—Organization,* the Division of Extension and Marketing, which has its headquarters in Port Moresby, operates through its Regional and District Agricultural Officers, together with their staffs of Agricultural Officers in districts and sub-districts, and indigenous Assistant Agricultural Officers and Fieldworkers. The Regional and District Agricultural Officers have the responsibility for organizing all aspects of extension and marketing with both expatriate and indigenous farmers, whereas the lower level intermediaries operate entirely with indigenous agriculturists.

Background information on indigenous agriculture was presented in the 1960-61 Annual Report. Some further general information is presented below under *Survey of Indigenous Agriculture.*

FIELD EXTENSION WORK

Basic to the activities of the Division are contacts with the people, largely at the village level. A large proportion of the work is therefore carried out through agricultural patrols and visits to villages and individual farms. This work is based on agricultural extension stations and centres, from which field officers go out on patrol and to which villagers come in for demonstrations and training.

There is usually one extension station in each district, and these combine the functions of static demonstration, farmer training, local experimentation, livestock breeding, and seed production and distribution. During the two years under review there was considerable expansion in the services provided by these stations, especially in the provision of facilities for farmer training.

Extension centres are small establishments which serve as local bases, at sub-district or area level, for activities including patrolling, rural organization and marketing assistance, field training and seed and planting material distribution. During the two years 1961-1963, new centres were established at Lumi, Vanimo and Amanab in the Sepik District, Aiome in the Madang District, Kabwum, Morobe and Mumeng in the Morobe District, Lufa, Gembogl and Kerowagi in the Eastern Highlands District, Wapenamanda in the Western Highlands District, Laiagam in the Southern Highlands District and Walo in the New Britain District.

A summary of field extension activities in 1962-63, and the numbers of extension stations and centres established at June, 1963, is shown in Table 133.

TABLE 133. AGRICULTURAL EXTENSION STATISTICS, 1962–63

District	*Number Extension Stations*	*Number Extension Centres*	*Number of Patrols*	*Number of Day Visits*	*Population Contacted*
Sepik	1	11	286	574	376,172
Madang	1	4	20	517	60,285
Morobe	1	8	356	2,735	715,200
Eastern Highlands	0	8	500	2,140	244,765
Western Highlands	2	5	30	685	202,530
Manus	0	1	35	111	18,000
New Britain	1	4	84	1,165	88,000
New Ireland	1	1	46	154	20,420
Bougainville	1	4	282	1,960	60,000
Southern Highlands	1	1	35	36	8,000
Northern	1	4	142	2,437	52,000
Milne Bay	0	6	101	557	77,750
Central	1	8	85	807	60,000
Gulf	1	3	23	583	6,100
Western	1	1	17	38	24,500
Total	13	69	2,042	14,499	2,013,712*

* In many cases villages were visited several times.

Plate 29. Agricultural fieldworker demonstrating the rich mulch formed under a *Pueraria* cover crop. (*Photo: D.I.E.S.*)

Plate 30. Trainees planting *Pueraria* cover crop in a coconut plantation. (*Photo: D.I.E.S.*)

Continuing expansion in field extension work is envisaged under the five year plan which began in 1961-62.

FIVE YEAR PLAN

A plan to intensify the agricultural exension work being carried out among the indigenous inhabitants was adopted for the five years beginning in 1961-62. The main points of the plan are—

(i) To increase the number of professional agricultural extension staff to about 240, including indigenous officers engaged on full time extension duties.

(ii) To build up the force of indigenous agricultural assistants to 900 so that there will be one to each 2,000 of rural population.

(iii) To establish two additional sub-diploma agricultural institutions to cater for indigenous youths whose academic studies terminate at first year secondary school, but who will have ability to absorb technical agricultural training.

(iv) To allow approximately 30 agricultural diplomates to graduate per year by 1966-67.

(v) To establish approximately 50 agricultural extension centres from which extension staff can operate and at which agricultural demonstrations on a small scale can be conducted.

(vi) To produce more visual aid material for use in contact work and agricultural training. This will include film strips and pamphlets dealing with the major cash and subsistence crops and with various agronomic and crop processing practices.

The results aimed at in this intensified agricultural extension programme are—

(i) An improved level of village subsistence;

(ii) A higher standard of living resulting from the introduction of superior cash crop varieties giving higher yields, and of better processing and marketing facilities;

(iii) A rural population better trained in the best methods of agricultural practice for their particular areas.

STATUS OF INDIGENOUS AGRICULTURE

Change in status of indigenous agriculture from a purely subsistence system to largely commercial enterprise is necessarily very slow, involving as it does a variety of traditional and social as well as economic considerations. Very appreciable progress has nevertheless been made in the development of cash farming, as shown below under *Development of Indigenous Agriculture*.

Land tenure systems have proved a complicating factor in development plans for the extension of perennial crops, and it has been considered necessary to provide for the introduction of a single system of land holding, regulated by the Administration, providing for individual titles. Land settlement, or re-settlement, schemes were initiated in the early 1950's to provide villagers in densely populated areas with blocks of land, to which they would have individual title, for the purpose of re-settlement and cash cropping. Early schemes were operated through lease of land to Local Government Councils for sub-lease to individuals.

Limited success of these projects led to a revised system in which blocks large enough to provide an economic living for a family unit are leased direct to individuals. Provision is made for planting of subsistence as well as cash crops to encourage the lessee to live on the block. Credit has also been made available to lessees to permit them to develop the blocks efficiently. Lessees are required to develop one-fifth of the area suitable for cultivation within five years, two-fifths within ten years, and three-quarters within twenty years.

Such blocks were first advertised in September, 1959, and by March, 1963, a total of 634 had been made available. The five year plan calls for a total of 7,500 blocks to be made available by 1967.

In addition to providing for re-settlement on a moderate scale, an important purpose of the scheme is to demonstrate the economic advantages of efficient cash-cropping of an area considerably larger than is normally cultivated by village people. This should provide an inducement to the general population to extend their planting and improve efficiency. The Extension Division has therefore given close attention to advisory services to lessees of re-settlement blocks. As yet, all settlers are in the early stages of development of their blocks, but many are making very good progress.

A more detailed review of this subject is given by R. J. Cheetham: "The development of indigenous agriculture, land settlement, and rural credit facilities in Papua and New Guinea," *Papua and New Guinea agric. J.* **15**: 67-78.

SURVEY OF INDIGENOUS AGRICULTURE

A comprehensive survey of indigenous agriculture in the Territory was undertaken to provide a contribution to the 1960 World Census of Agriculture conducted by the Food and Agriculture Organization of the United Nations and, at the same time, to provide basic data which could be used in refining Departmental planning for the advancement of indigenous agriculture.

The conditions of Territory farming communities meant that this was a complex project requiring the development of special sampling techniques and necessitating arduous field procedures. The work was carried out jointly by the Commonwealth Bureau of Census and Statistics, Canberra, which was responsible for planning, design and assessment; the Division of Extension in the Department of Agriculture, which provided the local knowledge of the cultivators and their methods and carried out the field work; and the Bureau of Statistics of the Territory, which carried out the overall correlating and collating functions. The whole of the field staff of the Extension Division was committed to the task of selection of sample areas and collection of data. Over the period of the survey, which lasted for 18 months commencing in December 1960, the extension staff of each district were fully taken up with survey work for three periods, each of about six weeks. In addition, for the whole period, three Headquarters officers worked full time on the planning of operations, checking the work in progress and conducting brief courses prior to each of the three visits which were made.

Geographically, the survey included the whole Territory of Papua and New Guinea with the exception of certain regions not fully under Administration control, certain areas affected by the disease Kuru, and the Port Moresby urban area, whose inhabitants no longer depend on gardening for subsistence. These excluded regions contain some 15.7 per cent. of the total population. The survey was concerned primarily with subsistence crops, even though portions of these crops may be grown for sale. Rice and peanuts which are normally considered as cash crops, but which are sometimes grown for subsistence, were also included. In addition, data were collected on certain demographic characteristics, livestock, implements, and sago production.

Data were collected on a sample basis. One hundred sample villages were selected from each of 50 geographical strata. Within these villages a representative sample of families was selected. This sample comprised 0.1 per cent. of the total population of the area surveyed. In order to measure all crops harvested in sample gardens during the survey year, three visits at six monthly intervals were made to each of the sample villages.

In addition to the main survey, two ancillary surveys were held. One of these was a survey of indigenously owned coconut palms and the other a survey of auxiliary primary production which was used to gauge the extent of dependence on sources of food supplies not measured in the main survey. Together with statistics of cash crops which are collected annually by the Department of Agriculture, these three surveys covered the whole field of primary production in the indigenous sector, with the exception of mining.

The survey showed an estimated 184,000 acres brought under cultivation and 178,000 acres cleared during the survey year, with the entire area in use at any time in the period being 545,000 acres. This represents 0.11, 0.10 and 0.32 acres per person respectively.

The most important crops planted during the year were sweet potato (105,000 acres, 1,201,000 tons production), bananas (60,200 acres, 610,000 tons), taro *Colocasia, Xanthosoma* and similar species (60,500 acres, 458,000 tons), sugar cane (7,900 acres, 307,000 tons), yams and mammies (18,400 acres, 233,000 tons) and sago (production 115,000 tons). Major implements in use were bush knives and axes (40 and 37 per hundred persons respectively), and the most important livestock were pigs and poultry (57 and 41 per hundred persons respectively).

Full details of methods and results of the survey have been published by the Bureau of Statistics, Papua under the titles "Survey of Indigenous Agriculture and Ancillary Surveys 1961-62" and "Survey of Indigenous Agriculture and Ancillary Surveys 1961-1962: Technical Document."

DEVELOPMENT OF INDIGENOUS AGRICULTURE

With the encouragement and assistance of Extension staff there have been steady advances in the development of indigenous agriculture. Reports are given below of the main trends in cash crop production in each District. It should be noted that most of the statistics quoted are estimates only, and in some instances may have to be revised substantially. For example, many coconut groves are not planted with any systematic spacing and it is not possible to determine numbers accurately. Production statistics also are never completely accurate, since frequently a proportion of indigenous production is sold to plantations and thereby confused with plantation production.

Some of the more outstanding advances in the two years under review were—

(1) A 200 per cent. increase in the numbers of coffee trees in the Sepik District from 93,000 at June 1961, to 310,000 at June 1963.

(2) More than 100 per cent. increase in cacao tree numbers in the Madang District, from 150,000 at June 1961, to more than 300,000 at June 1963.

(3) Almost 100 per cent. increase in cocoa production in the New Britain district, from 1,729 tons in 1960-61 to 3,267 tons in 1962-63.
(4) A 100 per cent. increase in cacao tree numbers in the Bougainville District, from 360,000 at June 1961, to 780,000 at June 1963.
(5) A 400 per cent. increase in coffee production in the Eastern Highlands District, from 326 tons in 1960-61 to 1,605 tons in 1962-63.
(6) A 200 per cent. increase in coffee production in the Western Highlands District from 70 tons in 1960-61 to 220 tons in 1962-63.
(7) More than 100 per cent. increase in cacao numbers in the Northern District, from 275,000 at June 1961, to 640,000 at June 1963.
(8) A 300 per cent. increase in coffee tree numbers in the Central District, from 32,000 at June 1961, to 115,000 at June, 1963.
(9) Copra production in 1962-63 was 11,393 tons in New Britain, 6,700 tons in New Ireland, 3,456 tons in Milne Bay, 1,897 tons in the Gulf and 2,360 tons in Bougainville.

Sepik District

More than 80,000 coconut palms were planted during the two years, bringing the total to 1,295,000. Copra production was 394 tons in 1960-61, 516 tons in 1961-62 and 350 tons in 1962-63.

Robusta coffee plantings increased from 93,000 in 1960-61 to 310,000 in 1962-63. Three tons of green coffee was produced in 1961-62 and 5 tons in 1962-63.

Rice plantings increased, with 70 tons produced in 1961-62 and 130 tons in 1962-63. This was milled and consumed locally.

Cacao plantings had increased to a total of 25,000 trees by June, 1963.

Adverse marketing conditions caused the virtual cessation of peanut production. Sales of truck crops in 1962-63 totalled 611 tons worth £11,500.

Crocodile skins worth £90,000 were sold.

Madang District

Coconut numbers were estimated at 1,057,000 and copra production was 1,500 tons in 1961-62 and 1,768 tons in 1962-63. Quality of copra also improved.

Cacao numbers rose from 150,000 in 1960-61 to more than 300,000 in 1962-63. Most of these trees were immature, but 25 tons of cocoa was produced in 1962-63.

Rice production was maintained at a fairly steady level, with 120 tons sold and more than 30 tons consumed by the growers in 1961-62 and an estimated production of 120 tons in 1962-63.

Both Arabica and Robusta coffee are planted in the district, the former in the Finisterre Ranges and the latter in the lowlands. By June 1963 there were more than 110,000 trees, mostly immature.

Fruit and vegetable sales in 1962-63 amounted to 520 tons.

Morobe District

Total coffee plantings numbered almost 2,250,000 and production of coffee rose from 310 tons in 1960-61 to 470 tons in 1962-63.

Coconut palm numbers were estimated at 533,000 at June 1963, following extensive plantings, especially in the Finschhafen area. Copra production increased from 365 tons in 1960-61 to 438 tons in 1962-63.

Cacao plantings rose to 223,400 and 12 tons of cocoa was produced in 1962-63, compared with 6 tons in the previous year.

Peanut production was 117 tons in 1961-62 and 250 tons in 1962-63.

Rice production amounted to 13 tons in 1962-63, and truck crop sales were estimated at 1,855 tons. Twelve tons of *Centrosema* seed was produced.

Interest in cattle projects was maintained, and there were six in operation at June, 1963. There were also 13 mechanical farming projects engaged in the production of food crops.

Manus District

Coconut planting continued, and palm numbers were estimated at 370,000. Copra production was 472 tons in 1961-62 and 612 tons in 1962-63. Improvements were made in coconut grove maintenance and copra quality.

Cacao plantings increased to 23,000 and cocoa production was 2 tons in 1961-62 and 5½ tons in 1962-63.

Robusta coffee plantings increased to 13,000 trees, none yet producing.

Sale of truck crops rose from 200 tons in 1960-61 to 380 tons in 1962-63.

New Ireland District

Planting of coconuts continued and palm numbers were estimated at almost 2,000,000. Copra production was 6,200 tons in 1961-62 and 6,700 tons in 1962-63.

Cacao plantings continued in areas previously established, and the total number was estimated at 152,000. Fifteen tons of cocoa was produced in 1962-63.

Coffee plantings increased to 57,500 and production was just commencing at June, 1963. Most of this is Robusta, but a small proportion of Arabica is grown at higher altitudes.

New Britain District

A census of coconut palms gave a figure of 4,693,000 and production of copra was 10,759 tons in 1961-62 and 11,393 tons in 1962-63.

Cacao plantings increased to 3,650,000 trees of which at least 650,000 are not yet mature. Cocoa production rose from 1,729 tons in 1960-61 to 1,943 tons in 1961-62 and 3,267 tons in 1962-63.

Coffee plantings increased to a total of 9,450.

Truck crop sales were estimated at 2,000 tons in 1961-62 and 2,650 tons in 1962-63. The Rabaul market had an annual turnover of more than £100,000.

Resettlement schemes in the Gazelle Peninsula (Vudal and Warangoi) were in general progressing satisfactorily. Plantings of cacao increased to 530 acres, with an additional 200 acres under shade ready for planting and 150 acres under subsistence crops. Loan money made available by the Administration was being put to good use, and some blocks were approaching the ideal of a model plantation.

Bougainville District

Coconut palm numbers were estimated at 1,450,000 and copra production was 3,100 tons in 1961-62 and 2,360 tons in 1962-63.

Extensive cacao planting brought tree numbers to 780,000. Most trees were immature, but 93 tons of cocoa was produced in 1962-63.

Coffee trees numbered 110,000, mostly still immature.

Rice production was 87 tons in 1961-62 and 124 tons in 1962-63. Truck crop sales totalled 124 tons in 1962-63.

Eastern Highlands District

Extensive coffee planting continued with an increase of about 1,500,000 trees bringing the total to 4,350,000. Production figures were 326 tons in 1960-61, 904 tons in 1961-62 and 1,605 tons in 1962-63. Hamlet pulperies proved popular, and the quality of coffee produced was high. Results of a campaign for quality improvement begun in 1961 are illustrated in Table 134.

TABLE 134. GRADES OF COFFEE RECEIVED AT GOROKA IN SELECTED MONTHS

Date	*Parchment Coffee Received (lb.)*		*Per cent. Grade Y*
	Grade X	*Grade Y*	
June 1961 ..	120,000	37,000	23.5
December 1961 ..	36,200	6,800	15.0
March 1962 ..	65,700	4,000	6.0
May 1962 ..	157,000	8,500	5.0
June 1962 ..	241,000	3,900	1.5

Peanut sales totalled 32 tons in 1961-62 and 39 tons in 1962-63. Production in 1962-63 would have been higher, but a prolonged dry season delayed plantings. Home consumption would have been more than twice the amount sold.

Passion fruit production increased substantially in 1961-62 to 467 tons but in 1962-63 the dry season adversely affected production, and sales to the pulpery were 220 tons.

There was a reduction in quantity of tobacco produced, but an improvement in quality of leaf due to better husbandry. There are now a number of proficient tobacco farmers who, with a little supervision, produce good quality leaf.

Sales of truck crops amounted to 2,300 tons in 1961-62 and 1,930 tons in 1962-63.

Ten cattle projects were in operation, and a further 13 in various stages of preparation.

Western Highlands District

Coffee plantings increased substantially to a total of 1,100,000 trees. More than half are not yet bearing, but coffee production amounted to 150 tons in 1961-62 and 220 tons in 1962-63.

Passion fruit production was about 110 tons in 1961-62 and 82 tons in 1962-63.

An estimated 200 acres of peanuts planted in 1962-63 were all consumed by the growers.

Truck crop sales, mainly sweet potato, amounted to 5,000 tons in 1962-63.

Ten cattle projects were commenced, two of which were stocked and were being well managed.

Northern District

Coconuts in the district are used primarily for subsistence, but 40 tons of copra was produced in 1961-62 and a similar quantity in 1962-63. Plantings totalled 156,000 at June, 1963.

Robusta coffee plantings increased from 327,000 trees at June, 1961, to 396,000 at June, 1963. Coffee production was 26 tons in 1961-62 and 41 tons in 1962-63.

Cacao plantings increased from 275,000 trees at June, 1961, to 640,000 at June, 1963. Production increased from 11 tons in 1960-61 to 20 tons in 1961-62 and 22 tons in 1962-63. Prolonged dry weather early in 1963 probably reduced production for 1962-63.

Production of rubber was adversely affected in 1961-62 by unfavourable weather conditions, but improved in 1962-63. Production was 6 tons in 1960-61, 5½ tons in 1961-62, and 14 tons in 1962-63.

Sixty tons of truck crops were sold in 1962-63.

A land settlement project developed at Sangara included 227 blocks suitable for indigenous development. These blocks vary in size from 20 to 51 acres and are suitable for lowlands crops. All had been leased by June, 1963, and cacao plantings were progressing satisfactorily.

Milne Bay District

Coconut palms numbered 1,385,000 at June, 1963, and copra production was 3,330 tons in 1961-62 and 3,456 tons in 1962-63.

Coffee plantings totalled 250,000 at June, 1963, and production increased from 11 tons in 1960-61 to 21 tons in 1961-62 and 32 tons in 1962-63. This included both Arabica and Robusta.

Cacao numbers were 6,750 at June, 1963, mostly immature, but 1 ton of cocoa was produced in 1962-63.

Truck crop sales amounted to 500 tons in 1962-63. Other sales included 2 tons of chillies, 5 tons of rice, and 30 tons of Damar gum.

Central District

Coconut palms numbered 600,000 at June, 1963, and copra production increased from 827 tons in 1960-61 to 1,100 tons in 1962-63.

Coffee plantings increased from a total of 32,000 (both Arabica and Robusta) at June, 1961, to 115,000 at June, 1963. Production was 6 tons in 1961-62 and 17 tons in 1962-63.

Rubber plantings amounted to 1,000 trees and one ton of rubber was produced in 1962-63.

Cacao trees numbered 2,890, all immature.

Rice production was 41 tons in 1962-63 and truck crop sales were 2,444 tons.

Gulf District

Coconut plantings totalled 1,688,000 at June, 1963, and copra production was 1,828 tons in 1960-61, 1,990 tons in 1961-62, and 1,897 tons in 1962-63.

Rubber trees numbered 14,600 and production was 18 tons in 1961-62 and 12 tons in 1962-63. A Project Manager was appointed to the District and, under his supervision, good progress was made in processing by the Papuan owners.

Coffee plantings were extensive, and numbers increased from about 7,000 at June, 1961, to 52,500 at June, 1963.

Ten tons of rice and 150 tons of truck crops were produced in 1962-63.

A resettlement scheme, with blocks suitable for rubber and Robusta coffee production, was making good progress.

Southern Highlands District

This is a relatively undeveloped area, but good progress was made. Coffee numbers increased from 5,000 at June, 1961, to 39,000 at June, 1963, nearly all still immature.

Sales of truck crops amounted to 300 tons in 1961-62 and 600 tons in 1962-63.

Western District

Coconut numbers were 365,000 at June, 1963, and copra production was 43 tons for 1962-63.

Coffee plantings numbered 3,400 trees.

A regular source of income in this District was from sales of crocodile skins, which were valued at £45,000 in 1962-63.

AGRICULTURAL TRAINING

Training is to be carried out at three levels, two of which were in operation by June, 1963, namely, elementary farmer training and sub-diploma courses. Full diploma courses will commence in 1965.

Farmer Trainee Courses of nine to twelve months duration are held continuously at extension stations and centres. Villagers are given instruction, demonstration and practical experience in the cultivation of the crops suited to their area. In addition, shorter courses are given on occasion on specific subjects such as rubber budgrafting, animal husbandry and copra production.

There were 678 trainees attending courses in June 1961, 896 in June, 1962 and 1,257 in June, 1963.

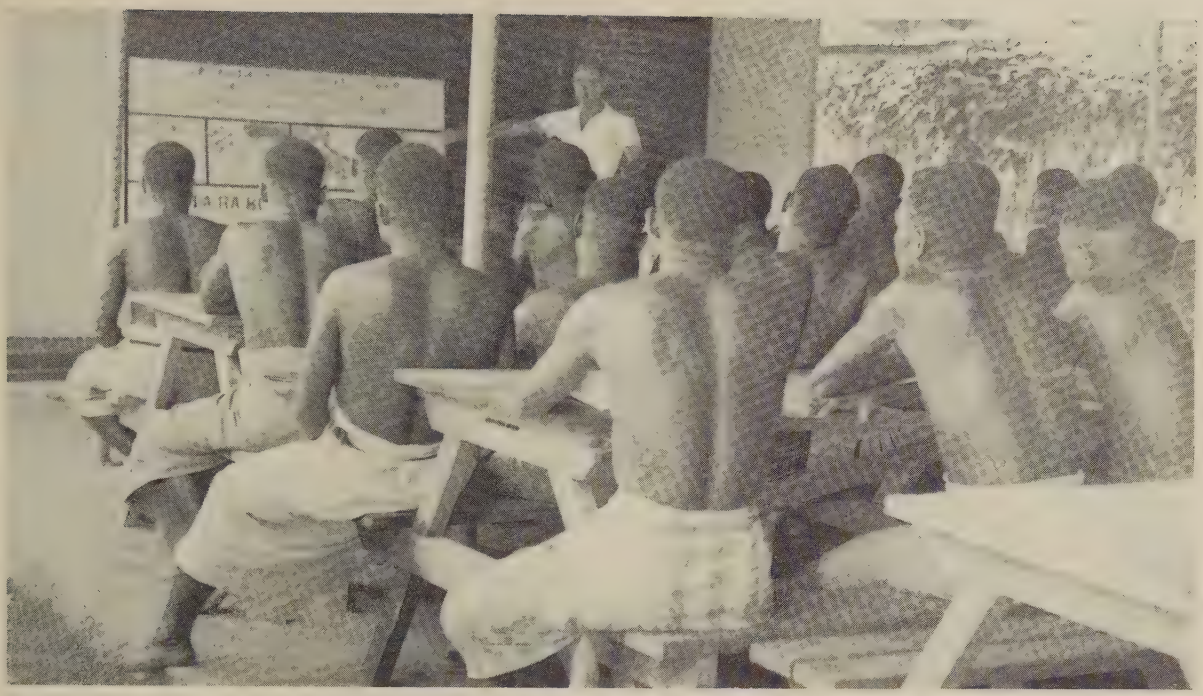

Plate 31. A class of farmer trainees and field workers receiving instruction in cacao growing, at Taliligap Agricultural Extension Centre, New Britain. (*Photo: D.I.E.S.*)

A Sub-Diploma Course of two years duration is given to students below Intermediate Certificate level. The course includes both theoretical and practical instruction in agriculture, botany, plant pests and diseases, agricultural economics, farming mathematics and English expression. In 1963, there were 17 first year and 27 second year students enrolled, with a staff of four expatriate and two indigenous teachers. The training was continued at Mageri up to June, 1963, but will be transferred to Popondetta in July on completion of buildings there.

Diploma Courses for students who have reached Intermediate Certificate level or its equivalent, will be given at Vudal Agricultural College, near Keravat, in the New Britain District. Initial development work has been carried out on the 700 acre site of the college and building contracts were let in February, 1963. Work commenced on College buildings in March, 1963, and the contract calls for their completion by August, 1964. The College should be available for in-service training courses in 1964 and the first diploma course is expected to commence in 1965.

In addition to basic training in agriculture, primarily for indigenous people, short orientation courses were given to new expatriate staff on arrival in the Territory. In 1963, forty extension officers attended a refresher course on subjects related to Administration assistance to Rural Progress Societies. The course was held at the Co-operative Education Centre, Port Moresby. The major subjects studied were the marketing of agricultural produce and book-keeping methods used by Rural Progress Societies. Other subjects included land classification, plant diseases and insect pests, and the training of indigenous agricultural field staff.

EXTENSION AIDS

A number of publications has been prepared for extension work. These include the following booklets, each published in simple English and in the trade languages, Pidgin and Police Motu—

" Grow Good Coconuts "
" Let's Make Good Copra "
" Let's Grow Peanuts "
" Let's Grow Good Robusta Coffee "
" Make Good Coffee "
" Grow Good Arabica Coffee "

In addition to these booklets there are a number of smaller information sheets on aspects of agriculture, produced on a Territory-wide or District level. The " Village Committee Book " is used in areas where extension work is organized through Village Agricultural Committees.

For agricultural training, "The Farmer Trainee Syllabus" and "The Kuiaro Book" have been published. The latter is a simply worded agricultural training text-book covering general agricultural principles and Territory crops.

All agricultural stations have libraries containing general reference books, and a number of periodicals are circulated regularly. Other books and periodicals are made available on loan from the Central Library on request.

"The Papua and New Guinea Agricultural Journal" is issued quarterly, and presents results of research, advice to primary producers, and review articles. It serves as an extension medium primarily for the dissemination of agricultural information to the expatriate farming community.

Films have also been prepared on different aspects of tropical agriculture, and they are in regular use. They include—

"Grow Good Coconuts"
"Make Good Copra"
"How to Make a Coffee Nursery"
"Care of the Coffee Tree"
"Village Coffee Factory"
"Cocoa".

Sound tracks are in both English and trade languages.

Increasing use is being made of radio as an extension medium, although the audience is somewhat limited as there is not a great number of radio receivers in rural areas. In the more sophisticated areas, such as the Gazelle Peninsula of New Britain, the radio audience is quite substantial. Departmental officers also contribute to radio programmes directed to the expatriate farming community.

Organizations such as Local Government Councils, Women's Committees, Village Agricultural Committees, Rural Progress Societies and Co-operative Societies are also used as a means of agricultural extension.

DEVELOPMENT OF MAJOR PROGRAMMES OF RURAL ORGANIZATION AND MARKETING

To cater for the considerable expansion of commercial production by indigenous farmers throughout the Territory, a series of major marketing projects has been organized on an area basis in various districts by the special marketing section set up within the Division of Extension and Marketing. The projects are integrated with the work on rural organization and marketing being carried out in connection with such organizations as Rural Progress Societies, Co-operative Societies, and Local Government Councils, and allow the development of individual enterprise within their framework. The following projects have been established:

Finschhafen Project

This project is based on the operations of the Finschhafen Marketing and Development Society Ltd., which has continued to consolidate its activities in the produce and marketing fields. The society, whose membership is drawn from all sections of the Finschhafen Sub-District, is organized on co-operative lines and supplies marketing services throughout the sub-district, including sea transport for coffee and copra; it also operates a wholesale and retail distributing service for consumer goods through branch stores. Agricultural extension activities at field level are integrated with Finschhafen Marketing and Development Society Ltd. operations to develop coffee pulping and copra curing techniques. A produce committee is established by Society rule and, by including agricultural extension and co-operative officers in its membership, provides managerial control over all produce marketing.

Inland Sepik Project

The project has been reorganised and now has one large Society handling rice, while two Societies have been put into recess, to be later re-activated as Robusta coffee production increases. A Project Manager located at the Bainyik Agricultural Extension Station, the focal point for these Societies, provides continuous guidance to them. An Administration central rice mill is located at the same station to process paddy rice marketed by the Societies. Production in 1961-62 was 74 tons of paddy rice and in 1962-63, 108 tons was produced. Robusta coffee production is slowly increasing. Two tons was purchased and exported by the Administration in 1961-62 and 3 tons in 1962-63. The marketing of this coffee is expected to be undertaken by the Societies in 1963-64.

Tolai Cocoa Project

The background to this project has been described in earlier reports. It involves the operation by Local Government Councils in the Gazelle Peninsula area of New Britain of central fermentaries for the processing and marketing of the crop from the very large cacao plantings in the area. The seventeen fermentaries processed 1,183 tons of cocoa in 1961-62 and 3,267 tons in 1962-63. One agricultural officer and two project managers give full-time assistance.

Asaro-Bena Project

Since the inception of this project in 1960-61, continuous assistance has been afforded to coffee, peanut, passionfruit and tobacco production. A programme for coffee quality improvement was pursued, the latest development being in the form of group action village pulperies. Tobacco production has remained small, providing excellent opportunities for research into smallholder cultural and curing techniques. The several tons of tobacco marketed were used in the manufacture of twist tobacco. Both peanuts and passionfruit received active encouragement though with peanuts little grower response resulted, despite attractive prices.

Chimbu Project

This is an extension of the Asaro-Bena activities and initial harvests of tobacco have been marketed and a number of village coffee pulperies has been promoted.

The Cupola Rubber Project

An Administration-owned rubber plantation at Cupola, near Kerema in the Gulf District, was leased to villagers for tapping, and processing facilities were made available. A nearby area of village plantation was included in the project for processing purposes. The factory was originally run by the Department, but from 1962 it was operated by the villagers themselves. They provide their own coagulating pans and pay 1d. per pound dry rubber produced as rental for other equipment. Rental on the trees is paid at the rate of 2d. per pound dry rubber produced. An agricultural field worker is stationed at Cupola to supervise field and factory operations.

Progress since inception of the scheme in 1960 has been fairly satisfactory, although problems have arisen between tappers and clan leaders over financial arrangements, and leases have not always been maintained in good condition. Production was 35,143 lb. sheet and clippings and 3,117 lb. scrap in 1961-62, and 25,000 lb. sheet and clippings and 2,200 lb. scrap in 1962-63.

Rural Progress Societies

The Sepik District's association of four coastal and three inland Societies had a turnover of 204 tons of copra in 1961-62 and over 300 tons in 1962-63. In Morobe District, the Bangalam Society continued to engage in the processing and marketing of rice, while three Societies engaged in copra and cocoa marketing at Morobe, Bukaua and Lei-Wompa expanded operations. Four Societies are operating in South Bougainville, one at Kieta and three in the Buin Sub-District. The Kieta Society is engaged in cocoa marketing while those in Buin Sub-District market rice, cocoa and basketware.

Co-operative Societies

The main activity of these Societies in relation to primary production is copra marketing. However, new Societies have been or are being formed to engage in coffee and cocoa processing and marketing. Continued assistance was provided in the form of training and advice in all areas of the Territory where they operate.

Direct Purchase of Cash Crops

The Department continued to assist in this way where other marketing facilities were not satisfactory. Crops to the value of £52,832 were purchased in 1961-62, and £75,624 in 1962-63.

OTHER SERVICES

Mechanization Services

Services to rural producers in regard to cultivation and processing equipment were maintained by Mechanical Equipment Inspectors located at Bainyik, Sepik District; Lae, Morobe District (from which two Inspectors serve the Morobe and Highlands Districts); Rabaul, New Britain District; and Port Moresby. Regional services were provided from Rabaul for the islands lying to the north of New Guinea; and from Port Moresby for the whole of Papua, excluding the Southern Highlands District.

Produce Inspection Service

All copra and cocoa for export is inspected by permanent staff at Lae, Madang, Lorengau, Kavieng, Rabaul, Kabakaul (near Rabaul), Port Moresby, and Samarai. Inspections are also made in the Bougainville District as necessary.

Central Processing Facilities

The operation of processing facilities continued, including coffee-hulling centres at Mount Hagen, Popondetta and Lae, and a rice-milling centre at Bainyik (Sepik District), and a peanut-hulling plant at Goroka.

DIVISION OF FISHERIES

Considerable advances in the knowledge of the biology of the commercial crayfish were made in the two year period, and the possibility of its economic exploitation was greatly advanced.

Further surveys of prawning grounds were carried out and some more probable commercial grounds were discovered, the best catches to date being recorded at Orangerie Bay. In addition, biological knowledge of the numerous species of prawns in the area was considerably increased.

Commercial exploitation of the barramundi of Western Papua was begun under the guidance, and with the assistance, of officers of the Division, and it was shown that economic fishing of this species is possible.

Further introductions of freshwater fishes were made, including two new species from Australia, the silver perch and the western carp-gudgeon. Golden Carp have now been distributed widely through the Highlands area for cultivation in private ponds.

FISHERIES—MARINE

During the year 1961-1962, marine surveys by F.R.V. *Tagula* were continued, directed almost entirely towards exploring prawning resources. From June 1962 *Tagula* was unavailable for research, as it was undergoing an extensive and prolonged refit, which had not been completed by June 1963. To replace it, M.V. *Climac's*, a 56 ft. Tweed Heads trawler, was chartered with Master and crew, and 10 voyages were undertaken in it. Prawns and crayfish again received special attention because of their potential economic significance to the Territory.

Shore-based operations also continued, despite a shortage of research staff for most of the period.

PRAWNS

Sixteen species of prawns were recorded in the 1960-61 Annual Report, and several new records were procured in the two-year period, while at least one more species can be added to the list of prawns present in commercial quantities. Most prawn surveys were concentrated on the Papuan coast, with one series extending to the vicinity of Lae. The main results may be summarized as follows:

(i) Considerable effort at Orangerie Bay confirmed the existence of small but apparently consistent commercial grounds. Catch rates exceeding 3 lb. per minute were recorded. The main species involved was the Banana prawn (*Penaeus merguiensis*), a shallow-water species forming about 50 per cent. by weight of the catch at 4 fathoms or less depth, but not occurring in commercial quantities in deeper water. In all large catches (greater than 1 lb. per minute) this species formed up to 95 per cent. or more by weight. The Tiger prawns, *P. monodon* and *P. semisulcatus*, made up most of the remainder of the catch in this area.

(ii) A small area of Banana-Tiger prawns with yields approaching 1 lb. per minute was discovered north of Yule Island. It has been shown that on these grounds commercial catches can be obtained close inshore by an outboard dinghy hauling scaled-down boards and 3-fathom trawl nets.

(iii) Definite indications of Banana-Tiger grounds were discovered off Kerema, with catch rates exceeding 1 lb. per minute. This area is so extensive that further surveys are required.

(iv) Commercial catches of Coral and Rainbow prawn (*Parapenaeopsis sculptilis*), exceeding 2 lb. per minute, were recorded off Cape Blackwood, on the western side of the Gulf of Papua. An entirely different prawn and trawl-fish fauna occurs in this turbid, low-salinity, blue-mud bottom area, including two species of spiny-backed prawn (*Atypopenaeus*) of which one is new to science.

(v) Several species of the genus *Metapenaeus* occur in New Guinea, but none has yet been found in commercial schools, although these and related species are economically important in Australia and elsewhere. It is possible that further grounds may be discovered for these types in appropriate seasons. The Greasy-back prawn (*M. ensis*), River or York prawn (*M. eboracensis*), and Green prawn (*M. demani*) have been taken in some numbers. *M. papuensis, M. saluensis* and *M. singaporensis* also occur in the Territory.

Certain other commercial-sized prawns have been recorded, notably the King prawns *Penaeus latisulcatus, P. japonicus,* and possibly *P. plebejus.* Although no quantities have been caught it is possible that night fishing may discover commercial potential.

CRAYFISH

Although the commercial Ornate or Painted crayfish, *Panulirus ornatus,* is a seasonally important food item on the Central Papuan coast, very little was known about its life-history and ecology. Attempts to catch the species in pots were unsuccessful, although it had been known to enter crab-traps occasionally. Its movements outside the seasonal " run " into shallow reef waters were not recorded, and the reason for this migration was unknown. Investigation showed the following results—

(i) Aggregations of this species occur in certain areas in October-November, before the seasonal run, in moderately shallow water (8-20 fathoms). These aggregations are reproductive, since early in the season, all crayfish taken are ripe, and most males are spent and most females impregnated or in berry soon after.

(ii) During this period commercial exploitation is particularly practicable, and on one occasion 600 crayfish (green weight 2,400 lb.) were landed in one hour by trawling. It is possible that methods such as trapping and ring-netting would also be effective in exploiting the breeding aggregations, and in fact consideration must be given to protecting the species at this vulnerable stage against excessive interference by bottom-trawling. These breeding schools are very mobile, at least overnight, since schools worked on one day could not readily be located the next.

(iii) It was discovered that this species of crayfish will readily enter baited pots placed in their vicinity. The main problem is to locate them first. From the few observations made, red meat Tuna bait is effective and shark-meat less so, but crayfish will attack dead sharks and other fish in nets, and are sometimes entangled in a mesh net overnight. The use of baited tangle-nets may be an effective technique for the exploitation of the seasonal run. Some crayfish stomach-samples examined contained a high proportion of small gasteropod shells, and it is possible that these molluscs form the bulk of their diet when obtainable.

(iv) The onshore " run " of crayfish following offshore breeding may be due to a food shortage caused by these schools, but there may be other factors also influencing the migration, such as change in water temperature when the prevailing wind direction changes. The inshore run is not consistent, being variously heavy or absent at different places each year. Observations of the breeding schools need to be carried on for several years not only to exploit them but also to discover the cause or causes of the inshore run. It should be noted that, as would be expected, crayfish in breeding schools are generally of far better quality than those taken by hand on reef in post-reproductive condition.

(v) The history of the crayfish stocks after the onshore run was unknown until it was shown that individuals could be caught in tangle nets in shallow water throughout the whole south-east season. It appears probable that the stocks disperse into inshore waters after the run onto the reefs, although it is possible that they also disperse offshore as well.

(vi) Possibly the most important predator of the ornate crayfish is the large sawfish, *Pristis microdon,* which is common in the inshore waters of Papua. One specimen trawled on cray grounds contained remains of three large crays, and recently-dead pieces of cray shell were frequently trawled up.

BARRAMUNDI

Barramundi research continued in the Western District both in estuaries and freshwater. An extensive patrol was carried out in M.V. " Emerald " during the first four months of the two year period, and subsequently a European officer was stationed in Daru specifically in connection with this research survey. The results of these surveys have been reported elsewhere (Dunstan D.J.: The Barramundi in New Guinea waters. *Papua and New Guinea agric J.* **15:** 23-31 (1962)).

Several commercial fishermen have shown interest in exploiting the Barramundi resources of the Western District, and with the assistance of officers of the Division, commercial fishing has begun.

OTHER SPECIES

Other commercial marine species taken in surveys included principally shark, mullet and trevally. Only very few commercial species were obtained during trawling operations, mainly shark, with occasional specimens of other species. A few trawls with a large-mesh fish-trawl were negative.

As in previous years trolling was carried out while travelling throughout all voyages, although pelagic fish were not generally sought, or worked if discovered. Under these conditions only a few fish were trolled, mainly mackerel, pike, trevally and tuna.

Handlining was carried out over reef in some areas, with poor results, of never more than 1 lb. per line hour and usually much less. The main species were various kinds of " reef-cod ", and occasional others.

OYSTERS

Oyster cultivation experiments at Milne Bay continued throughout 1961-63. Spat-collecting on cockle and coconut shells has been shown to be satisfactory, and growth rates of collected spat and wild oysters are now under study. A second study area has been undertaken at Kairuku in order to compare two different localities.

FISH PRODUCTS

Samples of fish meal of fair quality have been produced by fishermen in the Milne Bay District, using techniques demonstrated by the Division. As with other products of this type, the main difficulty is in marketing. Experiments were continued in the preparation of fish meal from the large numbers of trash fish caught during small-mesh trawling operations. Attempts to produce a commercial fermented-fish from this source were unsuccessful.

Many fish smoke houses built to designs suggested by the Division are now in operation, particularly in the Milne Bay District.

BECHE-DE-MER

A small commercial operation for beche-de-mer was begun by indigenous fishermen, with the assistance of the Division. Several small lots were marketed through the Department, but operations ceased within the two year period.

FRESHWATER FISHERIES

Several species of suitable freshwater fish have already been introduced into the Territory. These include the Giant Gouramy (*Osphronemus gouramy*), Snakeskin Gouramy (*Trichogaster pectoralis*), and several varieties of carp (*Cyprinus carpio*). Two species of trout (*Salmo gaidneri* and *S. fario*) have been introduced privately. During the two-year period a further importation of Giant Gouramy was made; and three Australian species were introduced, viz. Silver Perch, (*Bidyanus bidyanus*), which is an important angling, pond culture and commercial fish in Australia; Western Carp-Gudgeon (*Carassiops klunzingeri*), which is a prolific forage-fish; and the Tandan or Freshwater Catfish (*Tandanus tandanus*), which may be useful for pond culture.

The two gouramy species have not been bred in captivity but thriving wild populations of Snakeskin Gouramy have been discovered. About 4,000 Snakeskins were taken from a drying arm of the Waigani swamp and the species is also established at Lae and other coastal areas. Giant Gouramy up to 8 lbs. weight have been recaptured at Bomana Ponds. Tilipia has become abundant in many coastal localities, and is now widely eaten by indigenes. It is sold commercially at Koki market, Port Moresby, where it sometimes forms over 80 per cent of the daily sales in the south-east season.

None of the above species has been successful in Highland areas. Of the varieties of carp introduced, the Golden Carp has bred and grown very well in Highland areas, reported to have reached 12 lb. in 12 months, and has now been widely distributed. Great interest is now shown by Highland people of the Chimbu and Wahgi areas in pond cultivation of this species. Many carp up to 10 lb. weight are held at the Highlands Experiment Station.

The completion of the Sirinumu Dam during the period has made available a large body of fresh water close to Port Moresby, and the Division has taken steps to introduce fish and other aquatic animals in order to permit development as a fisheries resource. Large areas of the lake bed were cleared before filling began on 26th March, 1963. Fertilization of the lake during and after filling was carried out in bays prior to stocking as the lake waters are low in nutritional value for fisheries. Ecological studies have been carried out including surveys of autochthonous species, and of predators such as cormorants, and the following species have been introduced: Giant and Snakeskin Gouramy, Tilapia, Silver Perch and Carp-Gudgeon and *Macrobrachium*, the longarmed prawn. The Mosquito fish, *Gambusia affinis*, was introduced during the war years (1942-44) and although it served an extremely useful purpose at the time, it is now considered a severe hindrance to good fisheries development. Native Sunfishes (Melanotaeniidae) and Gobies occur in these waters, but they have not been observed to be as prolific as the small *Carassiops*. It is too early to ascertain whether any of the introductions has been successful.

Owing to shortage of qualified staff from the end of 1961, the Highlands Experiment Station has served purely as centre for distribution of carp, and research at Bomana Quarantine Ponds has been curtailed. At Kanudi Station studies of *Macrobrachium* and Atyid shrimps, with a view to pond cultivation for food and fish-food, have been undertaken. Ecological studies of autochthonous fishes have continued. A research museum collection of hydrobiological material has been begun and maintained. The Kanudi Gear Technology Section has continued to make and maintain nets and other fishing equipment and has successfully undertaken the building of several small plywood pram-type net boats.

ADMINISTRATIVE BRANCH

The organization of the Administrative Branch remained unchanged since publication of the 1960-61 Annual Report. For much of the two-year period, the Director, Mr. F. C. Henderson, was absent from the Department occupying the position of Acting Assistant Administrator. During his absence Mr. W. L. Conroy or Mr. A. W. Charles held the position of Acting Director.

Staff as at 30th June, 1963, comprised 58 officers and employees as follows—

Classification	*Permanent*	*Temporary*	*Exempt*	*Total as at 30th June, 1963*	*Establishment*
Biometrician ..	..	..	..	..	1
Agricultural Economist ..	1	..	..	1	1
Administrative Officer ..	1	..	..	1	1
Cadets	22	..	..	22	27
Libraries Officer	..	1	..	1	1
Clerks	7	2	..	9	13
Clerical Assistants	..	1	..	1	2
Clerical Assistants (Female) ..	..	3	..	3	5
Stenographer/ Typistes ..	1	1	..	2	5
Auxiliary Division	6	..	..	6	6
	38	8	..	46	62
Administration Servants	..	..	..	12	12
Total ..	38	8	..	58	74

Accommodation

The Administrative Branch is located in the Departmental Headquarters at Konedobu, Port Moresby. There was no expansion of office accommodation during the two-year period.

Cadets

One Veterinary and six Agricultural cadets completed their cadetships during 1961-62 and 3 Veterinary and 4 Agricultural cadets completed their cadetships during 1962-63.

Biometrician and Agricultural Economist

A newly appointed Agricultural Economist commenced duties late in July 1961. The position of Biometrician remained vacant for the 2 year period, but Mr. G. A. McIntyre of C.S.I.R.O., Canberra, continued to give the Department invaluable assisance in the field of design and analysis of experiments.

Library

The Department maintains a central library which receives over 400 periodicals and numerous pamphlets in addition to books. A continuous circulation of periodicals and books is maintained with District Agricultural Officers, Experiment Stations and Animal Industry Centres where Branch Libraries are maintained, the size and content depending on the number of officers and the type of work they are doing. All Branch Libraries are under the control of the Central Library.

Supply

The Supply Section processed 773 Indents and 1,288 local requisitions during the year 1961-62 and 892 Indents and 1,642 local requisitions during 1962-63.

Personnel

As at the 30th June, 1963, the Department had in its employ some 730 Administration Servants, as well as over 850 Farmer Trainees, and more than 950 general labourers. Second, Third and Auxiliary Division officers totalled 415.

The Personnel Section processed approximately 38 new permanent appointments, 13 temporary engagements and 28 resignations in the year 1961-62 and 39 new permanent appointments, 33 temporary engagements and 57 resignations in the year 1962-63.

Accounts

Departmental cash expenditure during 1961-62 was £1,107,524 plus capital purchases of agricultural machinery £18,726 and livestock £7,632, and livestock freight subsidy of £13,920. Vocabulary stores usage was £175,297. Total expenditure from all sources was £1,323,099.

Included in this expenditure were—

£12,161 for the operation of the Hallstrom Trust at Nondugl.

£66,546 for the purchase from Natives of cash crops for resale.

£26,533 for the payment of air freight and export duty on improved rubber seed from Malaya.

Receipts totalled £180,687 compared with £103,746 for 1960-61. The increase was caused in the main by the considerable rise in the volume of native cash crops sold, resulting from the heavy unsold stocks of these crops held at the end of 1960-61. Receipts for the sale of livestock rose by some £3,000 and sales of Station produced crops by over £6,000.

Departmental cash expenditure during 1962-63 was £1,224,779 plus capital purchases of agricultural machinery £24,935 and livestock £30,005, and livestock freight subsidy of £17,303. Vocabulary stores usage was £197,966. Total expenditure from all sources was £1,494,988.

Included in this expenditure were—

£1,137 for the operation of the Hallstrom Trust at Nondugl.

£75,624 for the purchase from Natives of cash crops for resale.

£7,085 for the payment of air freight and export duty on improved rubber seed from Malaya.

Receipts for 1962-63 totalled £145,711. The decrease was caused in the main by reduced sales of copra from Baibara Plantation which was sold during the financial year. Furthermore, revenue from resale of Native cash crops was not so high as in 1961-62 when it was inflated by carry-over of stocks from the previous year.

APPENDIX I

STAFF, DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES AT 30TH JUNE 1963

Director: F. C. Henderson, B.Sc.Agr. (Syd.), M.L.C.
Typiste: Miss S. M. Devine

HEADQUARTERS DIVISION

Agricultural Economist: G. R. Spinks, B.A., B.Ec., Dip. Ed. (Syd.)
Administrative Officer: V. S. Poole.

ACCOUNTS SECTION

Clerk (Accounts): N. T. Webster
Clerk (Accounts): H. J. F. L. Muskens
Clerk: Mrs. J. King
Clerical Assistant Grade II: Mrs. E. M. Kelly

PERSONNEL SECTION

Clerk (Personnel): P. A. Chandler
Clerk: N. S. Kenna
Clerk: P. M. Kysely
Clerical Assistant Grade III: J. W. Page
Assistant (Clerical): Kila Mega

STATUTORY REGISTRATION SECTION

Clerk: Miss W. E. Brown, B.Com. (Melb.)

RECORDS SECTION

Clerk (Records): Mrs. M. B. Reid
Typiste—Switchboard: Mrs. M. K. Harrison
Assistant (Clerical): Raka Ipi
Assistant (Clerical): Homoka Doriga
Assistant (Clerical): Morea Hila

SUPPLY SECTION

Clerk (Supply): G. R. Broadby
Typiste: Miss S. A. Gaul
Assistant (Clerical): Arua Rei

LIBRARY

Libraries Officer: Mrs. E. A. Anderson, B.A., Dip.Ed. (Qld.)
Clerical Assistant Grade II: Mrs. E. L. Murray
Assistant (Clerical): Pomare Bate

CADETS

Cadet Agricultural Officers—
R. G. Beneke:
P. R. B. Blood
H. Burton
G. P. Campbell
D. C. Cresswell
R. Doery
R. Donaghey
H. Gallasch
A. N. Gillison
G. D. Hill
M. Hunter
G. G. Johns
A. R. Lawson
Miss M. M. Mason
N. J. Mendham
J. Morgan
M. E. D. Reed
P. G. E. Searle
J. H. Sumbak

Cadet Veterinary Officers—
E. Fisher
A. M. Patton
P. K. Redman

DIVISION OF ANIMAL INDUSTRY

HEADQUARTERS

Chief of Division: J. L. Anderson, B.V.Sc. (Qld.)
Senior Stock Inspector: W. C. Jamieson, *Stock and meat inspection*
Veterinary Officer Grade III: T. L. W. Rothwell, B.V.Sc. (Syd.), *Veterinary services*
Typiste: Mrs. J. U. Harley

VETERINARY LABORATORY, KILA

Senior Veterinary Officer: J. R. Egerton, B.V.Sc. (Qld.), Dip. Bact. (Lond.), *Officer-in-charge, pathology and bacteriology services and research*
Veterinary Officer Grade II: Mrs. P. K. Abbott, B.V.Sc. (Syd.), *Pathology and bacteriology services and research*
Pathologist-Bacteriologist Grade II: Mrs. A. M. Rampling, B.Sc. (Nott.), *Pathology and bacteriology services and research*
Parasitologist Grade II: N. T. Talbot, B.V.Sc. (Qld.), *Parasitology services and research*
Field Supervisor Grade II: C. T. Coghlan, *Station manager*
Typiste: Mrs. A. M. Coghlan

CENTRAL DISTRICT

Stock Inspector Grade I: J. H. Gosbell, H.D.A., *Stock Inspector, Sogeri*

Papuan Lowlands Livestock Station, Moitaka

Livestock Officer Grade III: D. E. Murray, Q.D.A.H., *Station Manager*
Field Supervisor Grade I: D. Moodie
Field Supervisor Grade I: N. Nielson
Overseer: G. D. Gooding
Overseer: C. J. Collinson

Papuan Highlands Livestock Station, Bisianumu

Manager Grade III: D. P. McColm, *Station Manager*
Female Assistant: Mrs. E. I. McColm

MOROBE DISTRICT

Veterinary Services

Veterinary Officer Grade II: J. A. Hamilton, B.V.Sc. (Qld.), *District Veterinary Officer*
Veterinary Officer Grade I: D. J. Purdy, B.V.Sc. (Qld.), *Veterinary services*

Animal Industry Centre and Quarantine Station, Three Mile, Lae

Manager Grade II: J. L. Cunliffe, *Officer-in-Charge*
Stock Inspector Grade I: A. W. Marsh, Q.D.A.H.

New Guinea Lowlands Livestock Station, Erap

Animal Husbandry Officer Grade III: J. D. Glasgow, B.V.Sc. (Qld.), *Officer-in-charge*
Field Supervisor Grade III: B. I. Sutherland
Field Supervisor Grade I: C. R. Kempson
Overseer: P. A. Ireland
Female Assistant: Mrs. L. D. Kempson

EASTERN HIGHLANDS DISTRICT

Veterinary Services

Veterinary Officer Grade II: P. R. Harvey, B.V.Sc. (Syd.), *District Veterinary Officer*

Animal Industry Centre, Goroka

Manager Grade II: M. J. Lewis, *Station Manager*

WESTERN HIGHLANDS DISTRICT

Western Highlands Livestock Station, Baiyer River

Manager Grade III: W. N. St. George, *Station Manager*
Overseer: C. F. Clements
Overseer: I. W. Shaw
Overseer: K. R. Mills
Typiste Grade I: Mrs. M. St. George

Hallstrom Livestock Station, Nondugl

Livestock Officer Grade I: M. G. Meadows, Q.D.A.H., *Station Manager*

Veterinary Services

Stock Inspector Grade II: R. D. E. Rankin, Q.D.A.H., *Stock Inspector, Western Highlands*

NEW BRITAIN DISTRICT

Veterinary Services

Stock Inspector Grade II: A. R. Savage, *Stock Inspector, New Britain*

Animal Industry Centre, Kurakakaul

Animal Husbandry Officer Grade II: J. M. J. Best, B.A., Vet.M.B. (Cantab.), *District Veterinary Officer*
Field Supervisor Grade II: A. G. Howard, *Station Manager*
Overseer: A. E. Blumson

MADANG DISTRICT

Veterinary Services

Stock Inspector Grade III: F. L. Corbett, *Stock Inspector, Madang District*

SEPIK DISTRICT

Veterinary Services

Stock Inspector Grade I: C. W. H. Graham, *Stock Inspector, Sepik District*

DIVISION OF PLANT INDUSTRY

HEADQUARTERS

Chief of Division: A. W. Charles, B.Sc.Agr. (Syd.), M.Sc. (Cantab.)
Typiste: Miss M. G. Thomson
Typiste: Miss M. C. Blakeley

Agricultural Chemistry

Principal Chemist: D. W. P. Murty, B.Sc.Agr. (Syd.), *Soils and general chemistry*
Senior Chemist: P. J. Southern, B.Sc. (W.A.), *Plant nutrition*
Chemist Grade III: Miss P. M. Thorne, B.Sc. (Qld.), *General chemistry and pyrethrum analysis*
Chemist Grade II: Miss C. A. Fowler, B.Sc. (Melb.), *Plant analysis*
Chemist Grade II: C. C. Martin, B.Sc.Agr. (Syd.), *Soil analysis*
Chemist Grade II: G. Hart, B.Sc (S.A.), *Plant nutrition and chemical survey*
Laboratory Assistant Grade II: Mrs. D. A. Conyard, Dip. Chem.
Assistant (Higher Technical): Jeremiah Iewa
Assistant (Higher Technical): Peterson Ataembo

Economic Entomology

Senior Entomologist: J. J. H. Szent-Ivany, Ph.D. (Budapest), *Systematic entomology and zoogeography*
Entomologist Grade III: A. C. Catley, B.Sc.Agr. (Syd.), *Economic and systematic entomology*
Entomologist Grade II: L. Smee, B.Sc.Agr. (Syd.), *Economic and systematic entomology*
Assistant (Higher Technical): Edmund Kanjiri

Plant Introduction and Quarantine

Plant Introduction Officer, G. P. Keleny, B.A. (Qld.), D.D.A., *Plant introduction and exchange; plant quarantine*
Assistant (Higher Technical): John Tilip

Plant Pathology

Principal Plant Pathologist: Miss D. E. Shaw, M.Sc.Agr. (Syd.), Ph.D. (Man.), *Pathology and taxonomic mycology*
Plant Pathologist Grade II: M. J. Trinick, B.Sc.Agr. (Syd.), *Microbiology (Rhizobium)*
Plant Pathologist Grade I: W. A. Layton, B.Sc.Agr. (Syd.)
Laboratory Assistant Grade I: Horatius Igua
Assistant (Higher Technical): Reg Manuda

Soil Survey

Principal Soil Survey Officer: G. K. Graham, B.Sc.Agr. (Syd.), D.T.A. (Trin.), *Land use investigations*
Soil Survey Officer Grade III: A. C. Hartley, B.Agr.Sc. (Qld.), D.T.A. (Trin.), *Soil survey and drainage investigations*
Soil Survey Officer Grade II: F. P. Aland, B.Agr.Sc. (Qld.), *Land use and settlement investigations*
Soil Survey Officer Grade I: B. Unwin, B.Sc.Agr. (Syd.), *Soil survey and settlement investigations*
Assistant (Higher Technical): Forova Kulu
Assistant (Higher Technical): Iwa Alu
Assistant (Higher Technical): Noka Kopi
Assistant (Higher Technical): Seaka Kabua
Assistant (Higher Technical): Titus Tatauro
Assistant (Higher Technical): Babani Maraga
Assistant (Higher Technical): Ashby Sorof

RABAUL

Assistant (Higher Technical): Gumia Gitti, *Plant Quarantine Inspector*

EXPERIMENT STATIONS

Lowlands Agricultural Experiment Station, Keravat

Principal Agronomist: K. Newton, B.Sc.Agr. (W.A.), D.T.A. (Trin.), *Agronomist-in-Charge, cacao improvement and processing*
Principal Entomologist: G. S. Dun, B.Sc.Agr. (Syd.), *Economic entomology (biological control)*
Economic Botanist: A. E. Charles, B.Sc.Agr. (Syd.), *Coconut and cacao improvement*
Agronomist Grade II: J. B. O'Donohue, B.Agr.Sc. (Qld.), *Cacao improvement*
Agronomist Grade II: G. I. Jamieson, B.Agr.Sc. (Qld.), *Food crop and manila hemp improvement*
Agronomist Grade II: L. A. Douglas, B.Agr.Sc. (Qld.), *Coconut and coffee improvement*
Plant Pathologist Grade III: R. J. van Velsen, M.Agr.Sc. (S.A.), *Virology.*
Plant Pathologist Grade II: P. G. Hicks, B.Agr.Sc. (S.A.), *Cocoa pod rot studies*
Chemist Grade III: C. R. Levy, B.Sc. (Syd.), *Plant analysis*
Entmologist Grade I: A. G. Basson, B.Agr.Sc. (S.A.), *Economic entomology*
Horticulturist/Experimentalist Grade I: J. E. Hofman, Dip.Ag. (Deventer), *Cacao propagation*
Field Supervisor Grade II: R. J. Kelly
Clerk: L. C. Penders
Labour Supervisor: J. B. McNicoll, D.C.M. and Bar.

Plant Operator: L. Enkera
Mechanic: R. J. Lucker
Field Assistant Grade I: Orula Kakaito
Field Assistant Grade I: Mesulam Wanariu
Assistant (Higher Technical): Luke Maras

Highlands Agricultural Experiment Station, Aiyura

Principal Agronomist: R. S. Carne, B.Agr.Sc. (Melb.), D.T.A. (Trin.), *Agronomist-in-Charge, Coffee improvement*
Entomologist Grade III: J. H. Barrett, B.Agr.Sc. (Qld.), Q.D.A., *Pests of coffee and vegetable crops*
Agronomist Grade I: T. J. E. Quinlan, B.Sc.Agr. (Syd.), *Pyrethrum and food crops improvement*
Horticulturist/Experimentalist Grade I: K. H. van Horck, Dip.Hort. (Boskoop), *Coffee propagation*
Field Supervisor Grade II: H. Nitsche, Dip.Ag., *Livestock and pastures*
Assistant (Higher Technical): Konido Mara
Assistant (Higher Technical): Nou Matea
Assistant (Higher Technical): Sevese Meara
Assistant (Clerical): Soikava Forova

Agricultural Experiment Station, Epo

Horticulturist/Experimentalist Grade 1: E. Nihoul, Dip.Ag. (Carlsbourg), *Oil palm, manila hemp, sisal and coffee agronomy*
Field Supervisor Grade II: L. E. Andersson, *Rice breeding and agronomy*
Field Supervisor Grade I: A. J. van Kuyk, Dip.Ag. (Deventer)
Female Assistant: Mrs. E. A. Andersson
Carpenter: G. English
Assistant (Clerical): Nicholas Orina Poe

Plant Industry Centre, Bubia

Agronomist Grade II: C. S. Edwards, B.Sc.Agr. (Syd.), *Agrostology*
Agronomist Grade II: K. J. Blackburn, B.Sc.Agr. (Syd.), *Cacao and annual crops*
Agronomist Grade II: D. R. Petty, B.Agr.Sc. (Qld.), *Agrostology*
Field Supervisor Grade II: W. J. Hughes

Plant Introduction and Quarantine Station, Laloki

Horticulturist/Experimentalist Grade III: R. S. Montgomery, Q.D.H., *Station Manager*
Horticulturist/Experimentalist Grade I: R. G. Whalley, *Tobacco*
Technical Assistant Grade I: Kana Aburu

Rubber Centre, Bisianumu

Horticulturist/Experimentalist Grade I: E. Nihoul, Dip.Ag. Haaren, Dip.Hort. (Boskoop), *Rubber propagation and agronomy*

Experimental Tea Plantation, Garaina

Manager, Grade III: T. G. Henderson, *Station Manager, tea production and processing*
Field Supervisor Grade II: A. Hutton, *Tea production and processing*

Experimental Plots, Yambi

Field Supervisor Grade I: L. Finlay

DIVISION OF EXTENSION AND MARKETING

HEADQUARTERS

Chief of Division: W. L. Conroy, B.Sc.Agr. (Syd)
Principal Agricultural Officer: J. C. Lamrock, B.Sc.Agr. (Syd.), D.T.A. (Trin.)
Agricultural Officer Grade II: T. W. Langton, B.Agr.Sc. (Qld.)
Senior Mechanical Equipment Inspector: A. W. Jefford, M.I.A.E.
Typiste: Mrs. L. M. Stephens

Training Section

Principal Training Officer: S. P. Saville, B.Sc.Agr. (Syd.), D.T.A. (Trin.), Dip.Ed. (Syd.)
Agricultural Officer Grade I: C. J. Choat, B.Sc.Agr. (Syd.)

Publications Section

Senior Agricultural Officer: J. R. Vicary, D.D.A.
Assistant Clerical: Redmond Daingo

Marketing Section

Senior Agricultural Officer: M. J. B. White, D.D.A.
Agricultural Officer Grade I: B. J. Beil, Q.D.A.
Assistant Agricultural Officer: D. C. Furifuri
Typiste: Mrs. B. G. Green

CENTRAL DISTRICT

Senior Agricultural Officer: F. H. A. Kleckham, O.B.E., Q.D.A.
Agricultural Officer Grade III: W. R. Stent, B.Agr.Sc. (Melb.), D.T.A. (Trin.)
Agricultural Officer Grade III: G. N. Angell, M.D.A.
Agricultural Officer Grade II: F. J. Brockhall, Dip.Ag. (Deventer)
Agricultural Officer Grade II: J. C. Hall, D.D.A.
Agricultural Officer Grade I: C. C. E. Gahan, D.D.A.
Agricultural Officer Grade I: I. G. Pendergast, D.D.A.
Agricultural Officer Grade I: C. C. Abel, D.D.A.
Agricultural Officer Grade I: P. H. F. Beinssen, W.D.A.
Produce Inspector Grade II: G. W. Gaskell
Produce Inspector Grade II: W. H. Spencer
Produce Inspector Grade I: W. H. Hastie
Field Supervisor Grade II: W. A. Thistlethwaite
Mechanical Equipment Inspector: J. C. Harley
Mechanic: B. W. Strudwick
Clerk: B. J. Gough
Typiste: Miss A. J. Kirschner
Clerical Assistant: Mrs. E. A. Schulz
Assistant (Clerical): Tau Vagi
Assistant (Higher Technical): Geno Gideon
Assistant (Higher Technical): Kaekae Avaisa
Assistant (Higher Technical): Rupa Ora
Assistant (Higher Technical): Aloysius Fauma
Assistant (Higher Technical): Garo Lea

MILNE BAY DISTRICT

Agricultural Officer Grade III: K. I. Tomlin, W.D.A.
Agricultural Officer Grade II: P. E. Owers, Q.D.A.
Agricultural Officer Grade I: E. Mobbs, H.D.A.
Agricultural Officer Grade I: D. I. Murrie, R.D.A.
Agricultural Officer Grade I: H. P. Velacott, H.D.A.
Agricultural Officer Grade I: D. J. Underwood, Dip.Ag. (N.Z.)
Agricultural Officer Grade I: B. C. Teerink, H.D.A.
Produce Inspector Grade I: D. S. Askew
Produce Inspector Grade I: F. H. Carstensen
Assistant (Higher Technical): Annas Liasina
Assistant (Higher Technical): Charlesford Madiorote
Assistant (Higher Technical): Gabriel Nicholas
Assistant (Higher Technical): Nerius Tiotam
Assistant (Higher Technical): Saki Metu
Assistant (Higher Technical): Tommy Henry
Assistant (Higher Technical): Eliuda Weda

NORTHERN DISTRICT

Agricultural Officer Grade II: P. D. Ramm, B.Sc.Agr. (W.A.), D.T.A. (Trin.)
Agricultural Officer Grade I: M. K. Adams, W.D.A.
Agricultural Officer Grade I: R. J. Cheetham, B.Sc.Agr. (Syd.)

Agricultural Officer Grade I: J. Christensen, Q.D.A.
Agricultural Officer Grade I: D. Birmingham, Q.D.A.
Agricultural Officer Grade I: A. D. Hunt, M.R.A.C., A.I.C.T.A.
Agricultural Officer Grade I: A. R. Fischle, H.D.A.
Agricultural Officer Grade I: A. J. Kimber, B.Rur.Sc. (N.E.)
Project Manager Grade I: A. R. McCullough
Clerical Assistant Grade I: Mrs. N. Griffiths
Assistant (Higher Technical): Sixtus Baisiro
Assistant (Higher Technical): Luke Genau
Assistant (Higher Technical): Erico Foieke

Agricultural Training Institute, Popondetta

Lecturer: G. L. Edwards, H.D.A.
Assistant Lecturer: W. J. B. Heath, R.D.A.
Agricultural Officer Grade II: F. K. Mayer, H.D.A.
Field Supervisor Grade I: J. P. Swanston
Assistant Agricultural Officer: A. T. Luckie

WESTERN DISTRICT

Agricultural Officer Grade II: G. M. Hawley, M.D.A.
Agricultural Officer Grade I: A. J. Harrold, Q.D.A.H.
Agricultural Officer Grade I: J. C. Owen-Turner, Q.D.A.
Agricultural Officer Grade I: G. W. Greenwood, D.D.A.
Assistant (Higher Technical): Harold Kila
Assistant (Higher Technical): Latu Marivi

GULF DISTRICT

Senior Agricultural Officer: F. X. Ryan, H.D.A.
Agricultural Officer Grade II: T. W. Huthnance, H.D.A.
Agricultural Officer Grade I: W. H. Fullerton, Q.D.A.H.
Agricultural Officer Grade I: J. F. Clancy, W.D.A.
Project Manager Grade I: A. B. Wales
Assistant (Clerical): Kwapena Ravu

SOUTHERN HIGHLANDS DISTRICT

Agricultural Officer Grade II: H. A. Mulder, Dip.Ag. (Deventer)
Agricultural Officer Grade I: C. W. de Kantzow, H.D.A.

WESTERN HIGHLANDS DISTRICT

Agricultural Officer Grade II: M. H. M. Belfield, L.D.A.
Agricultural Officer Grade I: J. M. MacEwan, H.D.A.
Agricultural Officer Grade I: D. V. Slee, R.D.A.
Agricultural Officer Grade I: J. M. Fallon, L.D.A.
Agricultural Officer Grade I: S. Dopheide, Cert.Ag. (Deventer)
Agricultural Officer Grade I: G. P. Xavier, Dip.Ag., Dip.Dy. (N.Z.)
Agricultural Officer Grade I: L. N. Sewell, Q.D.A.

Korn Farm

Field Supervisor Grade II: J. G. Davis
Overseer: J. R. Fox
Female Assistant: Mrs. P. Davis

EASTERN HIGHLANDS DISTRICT

Agricultural Officer Grade III: B. A. Boniwell, B.Agr.Sc. (Melb.)
Agricultural Officer Grade II: D. J. Edwards, B.A. (Cantab.)
Agricultural Officer Grade II: K. G. R. Newton, Q.D.H.
Agricultural Officer Grade II: G. H. Dick, B.Sc.Agr.(Syd.)
Agricultural Officer Grade I: I. L. Thomas, R.D.A.
Agricultural Officer Grade I: J. J. Nitsche, Q.D.A.
Agricultural Officer Grade I: G. G. Collett, H.D.A.
Agricultural Officer Grade I: R. N. Amos, L.D.A.
Agricultural Officer Grade I: P. F. Koch-Emmery, B.Sc.Agr. (Syd.)
Agricultural Officer Grade I: R. J. Brown, H.D.A.
Agricultural Officer Grade I: J. M. Eccles, H.D.A.
Agricultural Officer Grade I: W. P. West-Newman, Q.D.A.
Agricultural Officer Grade I: R. F. McKillop, B.Rur.Sc. (N.E.)
Project Manager Grade III: R. B. Duncan
Assistant Agricultural Officer: W. Lawrence
Clerical Assistant Grade II: Mrs. A. T. Tuza

MOROBE DISTRICT

Senior Agricultural Officer: E. R. Wilson, Q.D.A.
Clerk: J. D. McMahon
Clerk: W. J. O'Donnell
Typiste: Mrs. M. M. Goudie
Typiste: Mrs. J. Trubert
Agricultural Officer Grade II: R. E. Curtis, D.D.A.
Agricultural Officer Grade II: J. A. Wallis, H.D.A.
Agricultural Officer Grade II: D. W. P. Macauley, H.D.A.
Agricultural Officer Grade I: P. R. Dillon, H.D.A.
Agricultural Officer Grade I: J. K. Oates, H.D.A.
Agricultural Officer Grade I: H. K. C. Dunstan, Q.D.A.
Agricultural Officer Grade I: B. J. Kebby, H.D.A.
Agricultural Officer Grade I: R. C. Henderson, H.D.A.
Agricultural Officer Grade I: C. J. Boston, C.D.A., N.D.A.
Agricultural Officer Grade I: W. B. Gliddon, R.D.A.
Agricultural Officer Grade I: K. J. Webster, Q.D.A.H.
Agricultural Officer Grade I: J. D. W. Ross, Q.D.A.
Agricultural Officer Grade I: L. G. W. Tilley, Q.D.A.
Agricultural Officer Grade I: I. D. Rowles, Q.D.A.
Agricultural Officer Grade I: R. A. Eivers, B.Sc.(Agr.) (W.A.)
Mechanical Equipment Inspector: A. G. Donaldson, A.M.I.A.E.
Produce Inspector Grade II: J. A. Phillips
Project Manager Grade II: T. Otterspoor
Field Supervisor Grade I: J. W. Bell
Assistant (Clerical): Gaudi Mirau

MADANG DISTRICT

Agricultural Officer Grade II: R. E. McCormac, H.D.A.
Agricultural Officer Grade II: F. Minchin, M.D.A.
Agricultural Officer Grade I: A. G. Govaars, W.D.A.
Agricultural Officer Grade I: J. C. van Schilfgaarde, Dip.Ag. (Deventer)
Agricultural Officer Grade I: G. J. Bastyan, M.D.A.
Agricultural Officer Grade I: P. R. Jones, Q.D.H.
Agricultural Officer Grade I: T. D. Joyce, R.D.A.
Produce Inspector Grade II: R. T. Collings
Manager Grade II: N. B. N. Blood
Typiste: Mrs. R. I. Bates

SEPIK DISTRICT

Agricultural Officer Grade III: D. R. Carey, Q.D.A.
Agricultural Officer Grade II: F. Arndt, Q.D.A.
Agricultural Officer Grade I: N. J. Cooper, Q.D.A.
Agricultural Officer Grade I: R. P. Scott, Q.D.A.H.
Agricultural Officer Grade I: W. J. McKean, L.D.A.
Agricultural Officer Grade I: R. W. Arnison, B.Sc.Agr. (Syd.)
Agricultural Officer Grade I: A. J. Whitton, H.D.A.
Agricultural Officer Grade I: D. C. Willis, L.D.A.
Agricultural Officer Grade I: J. J. Shipard, R.D.A.
Agricultural Officer Grade I: L. R. Brownhall, B.Sc.Agr. (Syd.)
Agricultural Officer Grade I: G. J. Harvey, H.D.A.
Project Manager Grade I: J. I. Burgin
Mechanic: H. G. Noy
Clerical Assistant Grade I: E. A. McArthur
Female Assistant: Mrs. E. G. Noy
Assistant (Higher Technical): Edward Nigea
Assistant (Clerical): Tore Reva

MANUS DISTRICT

Agricultural Officer Grade III: R. W. Cottle, Q.D.A.
Agricultural Officer Grade II: P. U. C. Hermann, Q.D.A.
Agricultural Officer Grade I: G. K. H. Chan, B.Sc.Agr. (Syd.)

NEW IRELAND DISTRICT

Agricultural Officer Grade I: R. C. McDonald, B.Agr.Sc. (Qld.)
Agricultural Officer Grade I: J. Curran, D.D.A.
Agricultural Officer Grade I: J. M. Adams, Q.D.A.
Agricultural Officer Grade I: L. L. Hughes, Dip.Ag. (N.Z.)
Produce Inspector Grade II: C. A. Reason
Produce Inspector Grade I: L. R. Noble
Project Manager Grade I: D. de Graaff

NEW BRITAIN DISTRICT

Principal Agricultural Officer: J. W. Barrie, B.Sc.Agr. (Syd.), D.T.A. (Trin.), Dip.Ed. (Syd.)
Senior Agricultural Officer: D. J. Kingston, Q.D.A.
Clerk: C. R. Fyson
Typiste: Miss R. Seeto
Agricultural Officer Grade II: D. C. A. Shepherd, M.D.A.
Agricultural Officer Grade II: B. R. Johnston, R.D.A.
Agricultural Officer Grade II: D. E. Montgomery, H.D.A.
Agricultural Officer Grade II: J. I. Cox, H.D.A.
Agricultural Officer Grade I: N. M. Alcorn, Q.D.A.H.
Agricultural Officer Grade I: B. Coghill, W.D.A.
Agricultural Officer Grade I: D. N. Brown, M.D.A.
Agricultural Officer Grade I: K. J. Witting, B.Sc.Agr. (Syd.)
Agricultural Officer Grade I: M. L. Jones, Q.D.A.
Agricultural Officer Grade I: J. F. Bent, Dip.Ag. (Essex)
Agricultural Officer Grade I: S. S. Rigby, B.Agr.Sc. (Qld.)
Senior Produce Inspector: F. A. Rhoades, D.S.C., H.D.A.
Produce Inspector Grade I: D. H. Maclean
Produce Inspector Grade I: L. R. Noble
Produce Inspector Grade I: D. S. Mullaly
Produce Inspector Grade I: Y. B. Donald
Produce Inspector Grade I: A. M. Squires
Produce Inspector Grade I: P. Reid
Produce Inspector Grade I: A. M. Wollaston
Produce Inspector Grade I: J. H. Wilkinson
Produce Inspector Grade I: J. H. Rudd
Produce Inspector Grade I: R. A. Pullen
Registrar/Manager: W. A. Ovenstone
Project Manager Grade I: C. L. Slinger
Mechanic: H. D. Watt
Mechanic: G. C. Wilks

BOUGAINVILLE DISTRICT

Agricultural Officer Grade III: M. J. Mead, R.D.A.
Agricultural Officer Grade II: L. F. Green, D.D.A.
Agricultural Officer Grade I: R. Tevlin, R.D.A.
Agricultural Officer Grade I: B. A. McBaron, Q.D.A.
Agricultural Officer Grade I: G. Tually, H.D.A.
Agricultural Officer Grade I: R. A. Porteous, D.D.A.

STUDENTS

Third and Fourth Division Staff receiving training at the Agricultural Training Institute

Baipara, Luscombe
Bart, Jolam
English, Gregory (Jr.)
Foieke, Simon
Ganubela, Jehosophat
Gau, Justus
Guguna, Jehosophat
Hau, Joseph
Kaioni, Edric
Kamalu, Tokau
Mage, Peter
Mesea, Mesea
Mopio, James
Muia, Gottae
Oata, Luis
Oata, Michael
Piki, Soldier
Soroda, Dixon
Tom, Nayala
Waninara, Simon

DIVISION OF FISHERIES

HEADQUARTERS

Chief of Division: A. M. Rapson, D.Sc. (N.Z.), *Commercial marine products. Introduction of fresh water fishes*
Biologist Grade I: L. W. Filewood, B.Sc. (Syd), *Officer-in-Charge, Kanudi Biological Station*
Technical Officer Grade I: C. R. McIntosh, *Gear Officer, Kanudi*
Technical Officer Grade I: A. G. Hinton, *Officer-in-Charge, Kairuku*
Fishing Master/Engineer: R. G. Gibson, *Master, F.R.V. "Tagula"*
Typist: Miss C. M. Steed

WESTERN DISTRICT

Technical Assitant Grade III: R. F. Price, *Officer-in-Charge*

MADANG DISTRICT

Technical Assistant Grade III: L. F. Malcolmson, *Officer-in-Charge*

APPENDIX II

OVERSEAS VISITS BY DEPARTMENTAL STAFF, 1961-63

The following list shows official visits made by officers of the Department to overseas countries, including Australia, during the two years. In addition, several officers visited agricultural and research institutions during periods of recreation leave.

The Director, Mr. F. C. Henderson, was a member of the Australian delegation to the meeting of the International Coffee Study Group in Washington.

Mr. W. L. Conroy, Chief of Division of Extension, was a member of the Australian delegation to the International Coffee Agreement Negotiating Conference at United Nations Headquarters, New York and meetings of the Preparatory Working Party of the F.A.O. Cocoa Study Group at Washington, Rome and Trinidad. He also attended a Senior Officers' Course at the Australian Administrative Staff College, Mt. Eliza, Victoria, the Australian Tariff Board hearing on rubber at Canberra, and the New Guinea Coffee Agents Association Meeting in Sydney, and represented the Department at the Commonwealth Extension Conference at Hawkesbury Agricultural College, New South Wales.

Mr. J. L. Anderson, Chief of Division of Animal Industry, atended the F.A.O. Third Far East Meeting on Animal Production and Health at Bangkok, Thailand, and the 1961 and 1963 Biennial Conferences of Commonwealth and State Veterinarians in Canberra.

Mr. A. W. Charles, Chief of Division of Plant Industry, was a member of the Australian delegation to the first meeting of the F.A.O. Coconut Working Party and the fourth meeting of the F.A.O. Group on Coconut and Coconut Products at Trivandrum, India.

Dr. A. M. Rapson, Chief of Division of Fisheries, attended the Tenth Pacific Science Congress at Honolulu, Hawaii.

Dr. Dorothy E. Shaw was a member of the Australian delegation to the first meeting of the F.A.O. Coconut Working Party at Trivandrum, India, and attended the Australian Plant Pathology Conference at Adelaide, South Australia. She also made inspection tours on coconut disease in the Philippines; on cocoa, rubber and oil palm diseases in Malaya; and on cocoa diseases at the Cocoa Research Institute, Ghana.

Dr. J. J. H. Szent-Ivany attended the Tenth Pacific Science Congress at Honolulu, Hawaii, as a delegate of the Australian Academy of Science and Chairman of the Standing Committee on Pacific Entomology. He also carried out bibliographical research at the Australian Museum, and studied entomological museum techniques with C.S.I.R.O., Canberra.

Mr. G. P. Keleny attended a meeting in Sydney of the Seed Storage Committee of the Australian Agricultural Council.

Mr. J. R. Egerton completed his Diploma of Bacteriology at the University of London, and attended the Australian Veterinary Association's 1962 Annual Conference in Melbourne, and the 1963 Biennial Conference of Commonwealth and State Veterinarians in Canberra.

Mr. J. D. Glasgow attended the Australian Veterinary Association's 1963 Annual Conference in Sydney.

Mr. A. Catley attended a meeting in Sydney of the Screw Worm Fly Sub-Committee of the Biennial Conference of Commonwealth and State Veterinarians, and travelled to Nigeria on secondment to the South Pacific Commission to collect predators of *Oryctes* and the giant snail, *Achatina fulica.*

Mr. A. E. Charles attended the Tenth Pacific Science Congress at Honolulu, Hawaii.

Post-graduate studies were undertaken by Mr. R. J. van Velsen at Cambridge, Mr. P. D. Ramm in Trinidad, Mr. C. S. Edwards in Costa Rica, and Mr. J. C. Lamrock in Brisbane.

APPENDIX III

PAPERS PUBLISHED 1961-63

PAPERS PUBLISHED BY OFFICERS OF THE DEPARTMENT

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——— (1962).—The development of a cattle industry in the Territory of Papua and New Guinea. *Papua and New Guinea agric. J.* **14,** (4): 133-40.

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——— (1962).—*Tiracola plagiata* Walk. (Lepidoptera: Noctuidae) a serious pest of cacao in Papua. *Papua and New Guinea agric. J.* **15,** (1, 2): 15-22.

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CHARLES, A. W. (1961).—Report on a visit to cotton growing areas of Queensland. *Papua and New Guinea agric. J.* **14,** (2, 3): 78-91.

CHEETHAM, R. J. (1963).—The development of indigenous agriculture, land settlement and rural credit facilities in Papua and New Guinea. *Papua and New Guinea agric. J.* **15,** (3, 4): 67-78.

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JAMIESON, G. I. (1963).—The preparation and germination of Besoeki coffee seed. *Papua and New Guinea agric. J.* **15,** (3, 4): 138.

JEFFORD, A. W. (1962).—Dugout canoes of Papua and New Guinea. *Papua and New Guinea agric. J.* **14,** (4): 167-76.

——— (1962).—Maintenance of farm machinery in Papua and New Guinea. *Papua and New Guinea agric. J.* **15,** (1, 2): 49-56.

KELENY, G. P. (1962).—The origin and introduction of the basic food crops of the New Guinea people. *Papua and New Guinea agric. J.* **15,** (1, 2): 7-14.

NEWTON, K. (1961).—Notes on the botany, breeding and establishment of oil palms and production of palm oil. *Papua and New Guinea agric. J.* **14,** (2, 3): 53-77.

RAPSON, A. M. (1962).—Shark attacks in New Guinea waters. *Papua and New Guinea agric. J.* **14,** (4): 141-50.

ROTHWELL, T. L. W. (1961).—Two animal parasites previously unrecorded in New Guinea. *Papua and New Guinea agric. J.* **14,** (2, 3): 129-30.

——— (1963).—New recordings of animal diseases. *Papua and New Guinea agric. J.* **15,** (3, 4): 137-8.

SHAW, DOROTHY E. (1962).—Coffee rust risk to Papua and New Guinea. *Highlands quart. Bull.* **3:** 9-10.

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——— (1963).—Plant pathogens and other micro-organisms in Papua and New Guinea. *Papua and New Guinea Department of Agriculture, Stock and Fisheries Res. Bull. No.* 1, pp. 1-78.

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SPINKS, G. R. (1962).—Prospects for tropical agricultural products in international trade. *Papua and New Guinea agric. J.* **15,** (1, 2): 39-48.

STENT, W. R. (1963).—The rationalization of peasant agriculture. *Papua and New Guinea agric. J.* **15,** (3, 4): 111-22.

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——— and ——— (1963).—Insects of *Saccharum* spp. in the Territory of Papua and New Guinea. *Trans. XI Soc. Sugar Cane Techn. Mauritius:* 690-4.

——— and Womersley, J. S. (1962).—First record of the gall-forming coccid genus *Apiomorpha* Ruebsaamen (Hemiptera, Coccidae) in Papua. *Papua and New Guinea sci. Soc. Trans.* **3:** 20-2.

van Velsen, R. J. (1961).—Marginal chlorosis, a seed-borne virus of *Arachis hypogaea* variety "Schwartz 21" in New Guinea. *Papua and New Guinea agric. J.* **14,** (1): 38-40.

——— (1961).—Cassia mosaic, a plant virus of *Cassia* spp. in New Guinea. *Papua and New Guinea agric. J.* **14,** (2, 3): 124-7.

——— (1961).—Little leaf of *Acalypha wilkesiana. Papua and New Guinea agric. J.* **14,** (2, 3): 128.

——— (1961).—Witches broom in pigeon pea induced by mealy bug infestations. *Papua and New Guinea agric J.* **14,** (2, 3): 129.

——— (1962).—Cowpea mosaic, a virus disease of *Vigna sinensis* in New Guinea. *Papua and New Guinea agric. J.* **14,** (4): 153-62.

van Wijk, C. L. (1963).—The soils of Bougainville Island—their distribution and main characteristics in relation to agricultural development. *Papua and New Guinea agric. J.* **15,** (3, 4): 123-32.

OTHER PAPERS OF DIRECT RELEVANCE TO THE TERRITORY

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Cummins, George B. (1961).—A new rust on *Finschia chloroxantha* in New Guinea. *Papua and New Guinea agric. J.* **14,** (1): 52.

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Tyler, Michael J. (1962).—Observations on the influence of frogs on the ecology of coffee plantations in the Western Highlands of New Guinea. *Papua and New Guinea agric. J.* **14,** (4): 151-2.

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APPENDIX IV

METEOROLOGICAL DATA

Rainfall records for the main Departmental Stations are given in Table (i). This table shows monthly rainfalls for 1961 and 1962 and average monthly rainfalls for all periods for which records are available. In most cases recording commenced only in relatively recent years.

Sunshine records for Aiyura, Bubia and Keravat are shown in Table (ii). Records are kept with Campbell-Stokes recorders. They are available for a few years only, and in some cases are not complete.

TABLE (i). RAINFALL RECORDED (INCHES) AT DEPARTMENTAL STATIONS

	AIYURA			BAIYER RIVER			BISIANUMU		
	1961	*1962*	*Average**	*1961*	*1962*	*Average**	*1961*	*1962*	*Average**
January ..	10.16	4.78	9.13	14.65	4.63	10.17	10.93	25.57	11.41
February ..	6.08	8.71	10.78	17.60	14.12	13.09	15.05	10.71	11.74
March ..	7.90	7.97	9.91	11.68	10.93	14.38	6.99	12.98	9.89
April	7.67	8.88	10.07	12.47	13.79	13.51	11.65	7.21	11.74
May	9.45	7.62	4.65	6.11	6.85	6.03	13.28	4.80	8.04
June	6.80	2.70	3.73	5.37	2.17	3.65	3.77	3.79	3.92
July	3.13	6.23	4.16	6.31	7.21	4.51	4.49	2.66	2.57
August ..	15.36	4.54	5.56	9.75	2.67	4.59	8.41	2.75	3.47
September ..	3.26	6.99	5.11	6.88	8.59	7.05	5.33	16.12	7.76
October ..	8.85	5.10	6.17	7.04	13.70	7.00	4.75	4.53	6.77
November ..	10.20	5.58	7.81	10.39	3.07	8.09	5.43	7.32	6.45
December ..	8.18	10.46	9.45	8.20	11.32	12.30	10.53	10.09	9.68
Total ..	97.04	79.56	86.53	116.45	99.05	104.38	100.61	108.53	93.44

* Average based on records for 1937–40 and 1944–62.

* Average based on records from 1955–62.

* Average based on records from July 1954, to December 1962.

	BUBIA			EPO			ERAP		
	1961	*1962*	*Average**	*1961*	*1962*	*Average**	*1961*	*1962*	*Average**
January ..	13.62	6.51	8.27	10.01	6.41	7.52	5.52	2.40	5.19
February ..	8.80	6.93	8.06	4.51	7.17	8.02	2.00	8.34	6.03
March.. ..	4.82	9.65	8.87	4.98	6.10	8.41	7.35	4.82	6.59
April	7.94	9.61	10.00	1.36	4.96	6.76	1.95	3.97	3.12
May	13.44	6.84	8.69	2.15	4.63	1.64	4.09	2.43	1.96
June	12.74	9.37	10.37	1.42	1.72	1.44	3.27	1.83	3.08
July	10.03	13.44	13.18	1.24	0.35	0.83	1.32	3.27	3.94
August ..	17.31	10.50	14.51	1.30	1.49	1.09	6.43	3.14	4.55
September ..	14.14	14.70	11.76	2.52	2.19	2.21	4.84	2.92	2.49
October ..	11.77	11.78	7.85	1.46	1.69	2.08	4.44	2.60	2.44
November ..	3.73	7.67	7.06	2.79	0	2.38	1.22	3.65	2.77
December ..	2.81	7.35	7.60	2.77	5.45	7.18	2.44	8.05	4.60
Total ..	121.15	114.35	116.22	36.51	42.16	49.55	44.87	47.42	46.76

* Average based on records from July 1949 to December 1962 except October 1949, April 1950 and March 1952.

* Average based on records from 1952 to 1962

* Average based on records from 1951 to 1962, except January–April 1957.

	GARAINA			GOROKA			KERAVAT		
	1961	*1962*	*Average**	*1961*	*1962*	*Average**	*1961*	*1962*	*Average**
January ..	7.57	8.44	8.35	8.26	4.72	8.82	18.12	6.81	9.81
February ..	13.36	8.41	12.12	7.73	8.70	11.06	16.16	7.95	9.50
March	5.59	10.29	10.22	5.43	7.04	9.96	13.50	9.34	11.27
April	11.68	13.13	10.98	8.05	8.96	9.37	12.19	10.41	11.96
May	17.42	11.13	7.34	7.69	14.54	4.78	12.14	11.93	9.08
June	5.82	5.82	5.34	3.78	1.71	1.97	6.54	10.52	6.49
July	5.90	8.49	5.70	1.58	5.00	2.13	3.87	8.26	6.59
August ..	9.15	9.17	5.99	7.23	4.14	3.24	11.74	3.64	6.27
September ..	7.27	13.80	8.22	6.87	3.77	4.06	5.33	15.58	8.08
October ..	10.38	10.71	10.30	11.21	7.36	5.89	4.19	11.24	8.61
November ..	15.56	12.31	11.67	7.80	4.46	6.40	8.75	6.20	10.67
December ..	10.42	9.82	12.55	4.79	16.37	10.03	11.46	11.79	10.14
Total ..	120.12	121.52	108.78	80.42	86.77	77.71	124.02	113.67	108.47

* Average based on records from 1949 to 1962

* Average based on records from 1946–62, except April-August 1947 and October 1950–April 1951.

* Average based on records from 1930–37 and 1950–62

	KURAKAKUAL			LALOKI			MOITAKA		
	1961	*1962*	*Average**	*1961*	*1962*	*Average**	*1961*	*1962*	*Average**
January ..	14.01	4.86	9.43	4.05	10.06	6.00	6.21	10.31	5.43
February ..	7.83	7.41	7.62	14.84	6.23	8.70	10.06	5.87	8.04
March	13.40	7.16	10.28	4.62	7.55	6.66	4.67	8.50	6.16
April	8.68	9.41	9.04	6.48	5.61	6.15	2.28	7.27	8.16
May	6.83	2.50	4.66	5.16	1.57	2.41	6.85	1.28	2.36
June	3.82	7.99	5.91	0.53	0.40	1.84	1.58	0.90	1.30
July	3.63	6.00	4.74	1.47	0.14	0.73	0.65	0.36	0.78
August ..	10.07	2.32	4.86	0.95	1.51	1.43	1.14	1.60	1.38
September ..	5.46	5.41	4.69	1.64	3.10	2.16	1.53	1.17	1.56
October ..	6.13	1.60	4.79	1.74	0.67	1.28	1.11	0.30	1.35
November ..	3.67	2.91	5.12	4.62	2.38	3.81	1.47	2.17	3.16
December ..	5.40	6.19	8.16	8.46	4.53	7.91	5.20	4.30	6.19
Total ..	88.93	63.76	79.30	54.56	43.75	49.08	42.75	44.03	45.85

* Average based on records from June 1960–December 1962 only, and is probably lower then normal.

* Average based on records from 1949–62.

* Average based on records from 1908–62.

TABLE (ii). AVERAGE DAILY SUNSHINE (HOURS) AT AIYURA, BUBIA AND KERAVAT

	AIYURA		BUBIA			KERAVAT		
	1961	*1962*	*1961*	*1962*	*Average**	*1961*	*1962*	*Average**
January ..	2.4	6.7	3.7	7.8	5.7	2.7	7.3	5.4
February ..	4.8	3.9	6.6	5.9	5.2	6.6	6.0**	5.7
March	5.0	4.4	7.2	6.0	5.6	3.8	6.2	4.9
April	5.4	4.1	5.5	6.0	5.6	4.9**	5.3	5.1
May	4.6	4.9	6.1	5.5	6.1	6.4	5.9	6.4
June	4.6	6.4	4.0	4.7	4.3	5.5	5.6**	6.1
July	5.1	4.4	3.8	3.6	3.9	5.8	6.1	5.9
August	3.9	5.2	3.6	4.7	3.7	4.9	7.0	5.7
September ..	5.2	3.7	5.2	5.1	5.6	5.6	6.1	6.2
October ..	5.2	5.6	6.7	7.1	6.5	4.7	6.8	6.0
November ..	6.0	5.7	7.4	7.2	6.7	5.6	5.0	5.7
December ..	5.8	3.8	7.7	5.9	6.6	6.5**	4.7	4.7
Average ..	4.8	4.9	5.6	5.8	5.4	5.2	6.1	5.7

* Average based on records from July 1951 to December 1962

* Average based on records from November 1954–December 1962.
** Incomplete recording—6 days missed in 1961, 20 days in 1962 (19 in June).

By Authority: A. J. Arthur, Commonwealth Government Printer, Canberra